DISSERTATION

TRACING HYDROSOCIAL CHANGE: SOCIAL CONSTELLATIONS OF WATER ACCESS AND ALLOCATION FOR OIL AND GAS DEVELOPMENT IN COLORADO

Submitted by

Karie Boone

Department of Geosciences

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Doctoral Committee:

Advisor: Melinda Laituri

Michael Carolan
LeRoy Poff
Lynn Hempel

ABSTRACT

TRACING HYDROSOCIAL CHANGE:
THE SOCIAL CONSTELLATIONS OF WATER USE FOR OIL AND GAS DEVELOPMENT IN COLORADO

Increasing water use for OG development in Colorado suggests a change in the social constellations of water governance. Colorado's water allocation institutions, practices and policies relationally shape and are shaped by water's biophysical movement over space and time through a *hydrosocial cycle*. The hydrosocial cycle (HSC) framework examines social complexity of water governance institutions by systematically analyzing institutional change and continuity to identify the causes and consequences of decreasing agricultural water access. Starting with history, change and continuity are operationalized through a historical institutional framework that systematically pinpoints institutional outcomes resulting from a particular sequence of events, policies and practices occurring in a unique context. This historical institutional analysis finds that social complexity can be measured more accurately by attending to relational and informal institutions, operationalizing the HSC framework to address ambiguities between historical policy and contemporary practices.

To capture social complexity, then, this research considers how objects in nature and society are relational so that their meanings and uses depend on human agency and context. Colorado's institution of water rights is relational in two crucial ways. First, formal institutions are shaped by their social, political, and environmental settings/contexts. Concomitantly, formal institutions are shaped by processes and interactions that link Colorado's energy and water institutions across policy topics and levels of government instead of viewing them as evolving in

isolation. A hydrosocial analysis additionally captures social complexity of water institutions through an examination of the often overlooked informal social processes occurring 'under the surface'. Informal institutions are nuanced norms, decision-making structures, unwritten rules and activities that shape and are shaped by agent's lived experiences. These informal dealings are consistently negotiated day-by-day, are not defined in formal laws, policies or organizational documents but help explain formal institutional change and actual policy outcomes. The integration of informal and relational institutions links the hydrological and social while further enriching our understanding of how increasing water use for OG extraction shapes agricultural water access and allocation in Colorado's rural communities.

The changing nature of water use is taking place in Colorado's rural agricultural regions and in appropriated river basins, the Colorado River in the western part of the state and the South Platte River Basin flowing through the eastern plains. This dissertation asks if agricultural water users in these basins and in Colorado's top OG producing regions, Weld and Garfield Counties, are experiencing changes in water access related to increased water use for OG development. It additionally examines the implications of these changes.

Each of the following chapters addresses this question while making theoretical and conceptual contributions to the HSC framework. The first two chapters utilize a comparative case study methodology to provide in-depth examination of the 'how' and 'why' of historical and political change processes, an important step in building understanding of Colorado's changing agricultural water allocation and access. A historical institutional analysis finds that social complexity can be measured more accurately by attending to relational and informal institutions.

Chapter two examines relational and informal institutions from the perspective of water users on the ground and in the field. Interviews qualitatively investigate if agricultural water users are experiencing changes in water access related to increased water use for OG. In response, four primary themes emerged from an analysis of interview data: decreasing and differential water access for producers, leasing land and water from municipal and industrial users, maintaining agricultural water rights, and balancing equity in water access. Findings illuminate the important and changing role Agricultural Water Supply Organizations (AWSOs) play in balancing equity in and maintaining water access for agricultural users.

Chapter three suggests attending to increasing social distance in the U.S, including the rural-urban divide, by infusing policies with rural understandings. An embodied and inclusive pedagogy encourages empathy so that fewer political divides surface when rural communities feel silenced and forgotten. Interdisciplinary learning paradigms should work to generate empathy so that urban-biased water policies and practices infuse understanding across difference and foster social cohesion.

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Alexandra and Sandra who supported me with love, wisdom, and compassion without which I would not have maintained my sanity. None of this would have been possible without my mother who worked seven days a week to help me through my undergraduate education, showed me what it means to be a strong, independent woman, and how to persist.

DEDICATION

To my mother

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Water institutions, practices and policies shape and are shaped by water's biophysical properties over space and time. Relational shaping of river flows, access and allocation institutions occurs through an analysis of historical change, politics, and informal institutions through a *hydrosocial cycle*. The hydrosocial cycle (HSC) demonstrates how different uses and physical manipulations of water produce different kinds of social relations, and vice versa (Linton and Budds 2014). In this way, all things are simultaneously social and natural so that changes in use, management, and governance of the water's biophysical properties produce distinct forms of hydrologic and social, or hydrosocial constellations (Latour 1993; Bakker 2003; Swyngedouw 2009). The HSC framework identifies formally recognized water institutions and policies in addition to the often overlooked informal social processes occurring 'under the surface'. Broadly, the HSC assists this investigation into how the social complexities of water access and allocation can be qualitatively measured and the outcomes of institutional change and continuity identified. More specifically, this dissertation harnesses the HSC framework as a backdrop to better understand the changing water flows toward increased use for oil and gas (OG) development in Colorado. It examines the resulting changes in water access and allocation for diverse water users and asks what this tells us about the political outcomes of Colorado's fluctuating system of prior appropriation.

Since the early 1990's, Socio-ecological systems (SES) theorists and scientists have examined hydrosocial change through feedbacks between societal and ecological processes. From foundations in ecological theories and concepts, SES research is considered part of a new ecology that "stemmed from observations that variability, disturbance and unpredictability are

not exceptions that ecological dynamics strive to redress, but rather are the underlying rules for biophysical dynamics" (Cote and Nitingale 2012:476; Holling 1987). Similar to the iterative hydrosocial cycle, SES literature identifies the feedback from human actions to the environment, and from the environment back to human action as the crux of generating system resilience. SES frameworks are complex adaptive systems with at least three different hierarchical levels, some form of continuity in space and time, a degree of overall system coherence that connects the elements of the system into an identifiable entity and usually a set of rules (institutions) governs the number and nature of interactions that involve human actors (Cumming et al. 2013; Redman et al. 2004; Folke, Berkes and Colding 2003).

Despite the similarities between frameworks, SES dos not adequately account for the social complexities of water institutions (Agrawal et al. 2001; Cleaver 2015; Pahl-Wostl et al 2012; 2012; Nadasdy 2003). To represent social complexity, this research considers how objects in nature and society are relational so that their meanings and uses depend on human agency and context (Carolan 2007; Thrift 2008; Macnaghten and Urry 2000). Colorado's institution of water rights is relational in two crucial ways. First, formal institutions are shaped by their social, political, and environmental settings/contexts. Concomitantly, formal institutions are shaped by processes and interactions that link Colorado's energy and water institutions across policy topics and levels of government instead of viewing them as evolving in isolation. A focus on institutional outcomes captures changing water use and access resulting from increased OG activities, emulating the complexity needed to build just water governance institutions that effectively navigate the interconnectedness of social and hydrological problems.

A hydrosocial analysis accounting for social complexity additionally includes water institutions as shaped and influenced by informal institutions in tandem with formal institutions

that fills the gaps and resolves ambiguities of formal rules (Waylen 2014). The collective actions of social groups, local knowledge, and regional relationships make and remake institutional frameworks that are time and location specific (de Koning 2014; Cleaver and de Koning 2015). In this way, prior appropriation is embedded in complex social relations where actor decision-making recursively interacts with changing institutional structures and political divisions. The integration of informal and relational institutions links the hydrological and social while further enriching our understanding of how increasing water use for OG extraction shapes agricultural water access and allocation in Colorado's rural communities.

Increasing water use for OG development suggests a change in the social constellations of organizational decision-making and water access. The changing nature of water use for OG is taking place in Colorado's rural agricultural regions and in appropriated river basins, the Colorado River in the western part of the state and the South Platte River Basin flowing through the eastern plains. OG users challenge agricultural water ownership and management, currently at approximately 75% state governed water. A change in use shapes a change in ownership so that energy companies control of water increases and so does their participation in the decision-making entities including agricultural water supply organizations, such as irrigation districts. Changes in use, management, and governance of the water cycle produce distinct hydrosocial arrangements.

Still, Colorado's Division of Water Resources considers water use for OG extraction activities as short-term and an insignificant percentage of Colorado's overall water consumption (Rein and Wind 2015). There is additionally no mention of concern about long-term OG water use impacts to rural communities in the Statewide Water Supply Plan (CWCB 2015). OG activities are not represented at the Basin Roundtables, a state initiated water governance

mechanism mandated to integrate bottom-up, local decision-making into the State's Water Plan. These are the predominant entities responsible for guiding water policy in the state. While Colorado's institutions were built on the premise of mining interests, the contemporary pace and scale of energy extraction represents a new phenomenon that has not been critically examined. The number of active OG wells in Colorado has increased from 22,500 in 2002 to 54,200 in 2017 (COGCC 2017). Throughout its lifecycle, each well uses between 3 and 8 million gallons, or between 9 and 24 acre feet of water (Goodwin et al. 2014)[1]. This dissertation asks if agricultural water users in Colorado's top OG producing regions, Weld and Garfield Counties, are experiencing changes in water access related to increased water use for OG development and examine the implications of these changes.

OG companies are part of a larger trend characterized by municipal and industrial water users purchasing water out of agricultural, challenging the viability of Colorado's agricultural production (CAWA 2014), and further reducing long-term economic options for rural communities. When rural communities feel silenced or forgotten in political processes, social distance increases between rural-urban populations (DelReal and Clement 2017). Social distance contributes to a growing trend of increasing tensions between rural and urban, conservative and liberal, immigrants and nationalists, U.S. residents with differing ethnicities, values, and socio-economic statuses (Blair 2017; Hanson 2017; DelReal and Clement 2017). In response, interdisciplinary learning paradigms have the potential to generate empathy so that water policies and institutions can be infused with rural understandings that bridge the growing socio-cultural divides.

[1] For context, one acre foot will supply two average families for a year.

Comparing oil and gas water access in Weld and Garfield Counties, Colorado

Two of Colorado's most productive OG fields span the U.S continental divide and two different river basins: The South Platte and Colorado located in Weld and Garfield Counties respectively (See Figure 1). Both rivers are situated in a snowmelt dominated climate regime and the state is dependent upon that snow for adequate water supply (USBR 2012).

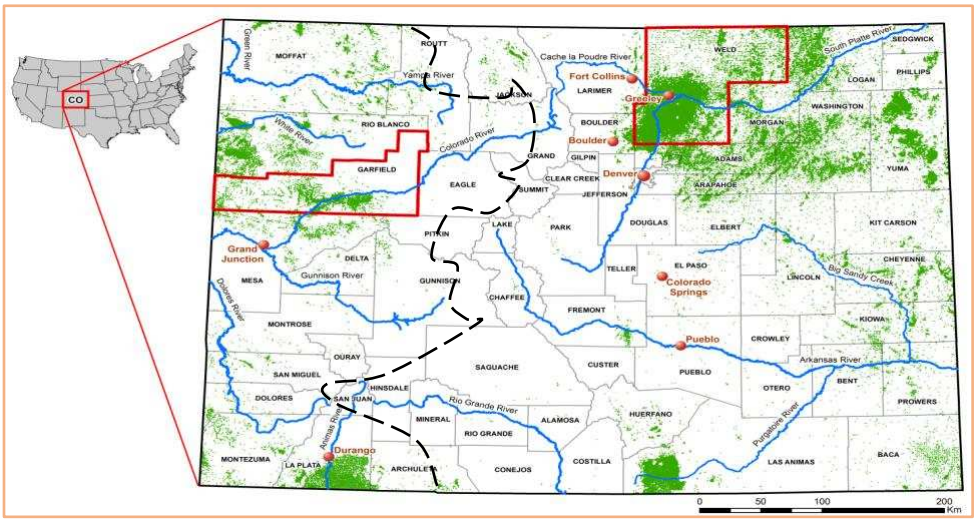

Figure 1.1: OG wells and river basins in Colorado counties. The green dots are OG wells. Garfield and Weld Counties are outlined in red and the Continental Divide is identified with a black dashed line. Data Sources: Colorado Oil and Gas Conservation Commission; Colorado Department of Transportation; U.S Geological Survey

Weld County

The South Platte River flows east of the continental divide across Colorado's Front Range, through Weld County and east to Nebraska. The river supplies the greatest concentration of irrigated agricultural lands in Colorado with 85% of water used to irrigate 831,000 total acres representing 24% of the state's irrigated acres (CWCB 2015). OG development began to surge in the early 2000's and Weld County is the top producing county with 23,160 active oil and gas wells (COGCC 2017). The South Platte is over-appropriated, meaning that in average years there

are more legally sanctioned water uses than there is available water. OG operators are nevertheless able to access water for HF. According to data collected from state databases, operators and private entities including water haulers, municipalities and increasingly from stakeholder-driven irrigation and reservoir companies purchase water rights from agricultural users. OG operators also secure short-term leasing arrangements including SWSPs from these same private entities and pay anywhere from $300 to $3,500/af of water. This is in contrast with the $35/af paid by agricultural producers in the same region.

Water is both native to the South Platte and diverted from the Colorado River Basin through the Colorado Big Thompson (CBT) project. CBT water is diverted from Western Colorado, under the continental divide and into the South Platte. Importantly, water is designated as multi-use, meaning it can be leased to diverse use types (i.e., municipal, industrial, irrigation) without long and costly water court change of use cases.

Garfield County

On the west side of the continental divide on Colorado's western slope, Garfield County is the second largest OG producing county after Weld with 11,220 active wells (COGCC 2017) and located on the main stem of the Colorado River Basin (CRB). The main stem of the CRB has 310,854 or 8% of the state's irrigated acres of farm and ranch lands (USDA 2014). OG operators lease small amounts of CRB water from private entities including ranchers and conservancy districts but mostly own water rights secured beginning in the late 1940's oil shale boom. Both Garfield and Weld case studies are rooted in unique contexts and histories while operating under the same water administration system, the system of prior appropriation.

The Road Ahead

Each of the following chapters stands alone as its own unit with its own sub-sections, figures and tables. HSC is used as a guiding framework to which each chapter makes a conceptual contribution. The first two chapters utilize a comparative case study methodology to provide the necessary in-depth examination of the 'how' and 'why' of historical and political change processes, an important step in building understanding of Colorado's changing water allocation and access. The third chapter tackles a learning theory that proposes an embodied and inclusive pedagogy to foster empathy so that policies can be infused with rural understandings, bridging the growing socio-cultural divide fostering long-lasting environmental commitments. Each chapter has already or is in the process of being submitted for publication.

Following this introduction, chapter two develops a framework for historical institutional analysis, operationalizing a relational approach to institutional development and change. HI is an organizing framework to analyze intersecting federal, state, and water-energy policy processes, identify socially and politically contingent sequences of events, political paths, and policies to show how past decisions shape contemporary institutional outcomes (Hacker 1998; Steinmo 2008; Thelen 1999). In this case, institutional outcomes include types of flexibility experienced in water right ownership and use. We discover that divergent political and economic histories in Weld and Garfield Counties have shaped distinct types of flexibility in water access mechanisms. Increased flexibility facilitates multiple uses of water where policies favor the most economically lucrative beneficial uses and create issues of transparency. We find that consideration of informal (Cleaver and de Koning 2015) and relational institutions more accurately captures outcomes of institutional change and continuity in resource governance institutions. A focus on historical transitions and their institutional outcomes helps to inform policy for future water access and

transparency. As water policy continues to adapt toward more flexible access, we call for more explicit institutional support to assess the social and environmental impacts of these changes. This chapter is published in *Society and Natural Resources*.

Chapter three presents themes and analysis from 42 interviews with ranchers, farmers, and water managers to qualitatively capture how OG water use is iteratively shaping agricultural water-related social organizations in Weld and Garfield Counties, Colorado. The research asks if agricultural water users are experiencing changes in water access related to increased water use for OG. What are the implications and consequences of these changes? In response, four primary themes emerged from an analysis of interview data: decreasing and differential water access for producers, leasing land and water from municipal and industrial users, maintaining agricultural water rights, and balancing equity in water access. Descriptively, findings show that in some cases water use for OG supports continued agricultural water use. Producers and their water supply organizations enter short-term water leasing agreements with OG companies that generate income used to make irrigation infrastructure improvements pay off loans early, and pay annual membership administrative fees, or 'assessments', saving money members would otherwise be responsible for paying. In these ways, OG contributes to farmers and ranchers maintaining water access through stakeholder-driven Agricultural Water Supply Organizations (AWSOs), including producer-run irrigation, ditch, and reservoir companies. AWSOs administer approximately 75% of the state's water supplies (CWCB 2015) and play an important role in leasing and selling water to OG operations. Paradoxically, interviews reveal that energy companies contribute to decreasing and differential water access for agricultural users. Companies buy up land and water, contributing to increasing regional land and water prices, challenging access for agriculturalists.

This research illuminates the important and changing role AWSOs play in balancing equity in and maintaining access to water for agricultural users. As OG developers purchase water rights, they become shareholders in previously agricultural-dominated AWSOs. With OG purchasing more shares in irrigation, reservoir and ditch companies, they will have more decision-making within these organizations. While Garfield and Weld Counties are located on different sides of the U.S Continental Divide, maintain different histories and river basins, AWSOs in both counties are similarly working to balance equity in agricultural water access.

Chapter four further accounts for the social complexities of hydrosocial configurations by developing an interdisciplinary pedagogy that generates empathy between learners and between learners and any resource of concern. The outcomes of OG extraction policies and practices shape agricultural water access and administrative flexibility in Colorado's rural communities. Such policies contribute to increasing social distance between rural-urban populations when rural communities feel silenced or forgotten in the political process (DelReal and Clement 2017). This divide is part of a growing trend of increasing tensions between rural and urban, conservative and liberal, immigrants and nationalists, U.S. residents with differing ethnicities, values, and socio-economic statuses (Blair 2017; Hanson 2017; DelReal and Clement 2017). In response, interdisciplinary learning paradigms have the potential to generate empathy so that policies can be infused with rural understandings, bridging the growing socio-cultural divide and fostering long-lasting environmental commitments. This chapter unpacks, analyzes and redefines reductionist SES education theories and proposes that we move toward more effectively shaping long-lasting commitments to the environment and others through an embodied and inclusive pedagogy.

I present an embodied and inclusive pedagogy that validates knowledge gained from sensual interactions with the environment and the experiential and interactional knowledge gained through learners diverse lived experiences. Sensory-based field experiences in science education that help learners navigate multiple epistemologies and physical interactions with nature increase learners' emotional connection and long-term behavior change in relation to the environment, other people (Frisk and Larson 2011; Jones et al 2012; Buxton 2007). Pedagogies should thus avoid separation of learners from sensory-based experiences, which contributes to the emotional, intellectual and cultural distancing in their understanding of and relationship to the environment (Pretty 2002; Morgan et al. 2006), and instead consider embodied and inclusive learning methods. Finally, chapter five concludes with theoretical and practical implications of this research.

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CHAPTER 2

ACCESSING FLEXIBILITY: A HISTORICAL INSTITUTIONAL ANALYSIS OF WATER USE FOR OIL AND GAS DEVELOPMENT IN COLORADO

U.S. Mountain West water access and allocation institutions have a history of adapting policy and practice to increase flexibility for diverse water uses. We examine how flexible access has developed over time and space by operationalizing the historical institutional (HI) theoretical and methodological framework. We trace historical water access for oil and gas (OG) development in Colorado, working from contemporary water right data to examine historical critical events, policies and political contexts. OG water use has iteratively shaped water governance institutions in the top OG producing regions of Colorado, Weld and Garfield Counties. The analysis suggests that to more accurately capture institutional change and continuity in resource allocation systems, an analysis of informal institutions is an essential theoretical contribution to the HI framework. While increased flexibility makes multiple uses easier, policies favor the most economically lucrative beneficial uses and generate issues of transparency, an important consideration for the public's resource. Future practices of flexibility are contingent on market structures and institutional access mechanisms shaped during previous government policy processes, illuminating the value of the HI framework to inform future water policy.

Introduction

Water policy and governance research argues for the creation of flexible institutions that have the capacity to adapt to increasing environmental and socioeconomic uncertainties such as

climate change (Folke et al. 2005; Pahl-Wostl 2012; Gallaher et al. 2013). In Colorado water law, flexibility emanates from water rights that can undergo a change in use type (municipal, industrial, agricultural) while preventing injury to other water right holders[2]. Colorado's water right administration system has foundations in a wide distribution of rights, serving diverse water right holders and regulating speculatory control of water resources (Schorr 2012). The legal attempts to adhere to these principles leave scholars arguing that the state's system of prior appropriation constrains adaptation and change (Gallaher et al. 2013). In this study, we hold a magnifying glass over the historical development of flexibility in Colorado's water rights system. We examine how oil and gas companies have accessed water for hydraulic fracturing (HF) between 2000-2015 in Colorado's two top oil and gas producing counties and make theoretical contributions that better explain continuity and change in resource governance institutions.[3]

We harness the historical institutionalist (HI) framework as a theoretical and methodological tool to trace policies and practices that have increased flexibility in Colorado's water right administration system. In our case study, flexibility is twofold: 1) the capacity of institutions to adapt to changing socio-economic and environmental conditions; and 2) the application of water rights to multiple uses. HI is an organizing framework to analyze intersecting federal, state, and water-energy policy processes, identify socially and politically contingent sequences of events, political paths, and policies to show how past decisions shape contemporary institutional outcomes (Hacker 1998; Steinmo 2008; Thelen 1999). In this case, institutional outcomes include types of flexibility allowing OG companies to access water. We

[2] *Empire Lodge Homeowners' Association v. Moyer*. 2001

[3]Once a horizontal well is drilled approximately 5000 feet deep, hydraulic fracturing injects a mixture of water, sand and a combination of different chemicals into a targeted OG bearing formation. High injection pressures cause the rock to fracture and release OG (Cheremisinoff and Davletshin 2015).

discover that divergent political and economic histories in Weld and Garfield Counties have shaped distinct types of flexibility in water access mechanisms. A focus on historical transitions and their institutional outcomes informs future water policy and uncovers issues of transparency.

HI traditionally focuses on formal institutions to explain outcomes of institutional change (Mahoney & Rueschemeyer 2003; Skocpol 1979; Goldstone 2003; Mahoney 2003; Brenner 1985; Anderson 1974; Tilly 1975). We use the Colorado case to operationalize the HI framework and find that consideration of informal and relational institutions also play an important part in explaining these outcomes. In addition to formally recognized water laws and policies, institutional outcomes are informally shaped and influenced by power struggles, actors drawing on formal institutional rules, local knowledge, and regional relationships to make and remake institutional frameworks that are time and location specific (de Koning 2014; Cleaver and de Koning 2015). To connect policies with outcomes, Colorado's institution of water rights is *relational* in two crucial ways. First, formal institutions are shaped by their social, political, and environmental settings/contexts (Thelen 1999). Concomitantly, we push the HI framework to consider formal institutions as shaped by processes and interactions that link Colorado's energy and water institutions across policy topics and levels of government instead of viewing them as evolving in isolation. This paper fills theoretical gaps in the HI framework by demonstrating innovative ways to understand informal and relational institutions, more accurately tracing historical change in flexibility allowed under the system of prior appropriation, how it has developed differently in Colorado's top OG producing communities, and what this means for institutional outcomes over time and space.

The paper flows chronologically following a description of the HI framework and its theoretical components, our data collection methods, and an analysis identifying the

contemporary water access mechanisms used by OG companies. We uncover current trends in OG water access strategies from Weld and Garfield Counties based on our research of Colorado State Division of Water Resources databases. A brief overview of Colorado's water policy system prepares the reader to engage with its complexity.

The theoretical analysis begins by chronologically tracing the historical institutional origins of prior appropriation. This sets the stage for an examination of federal energy policy processes and the socio-political context driven by nationalization of energy resources, pertinent in shaping water right ownership and engraining a particular type of flexibility. The 1969 Water Rights and Determination Act is then considered for its role in increasing flexibility while also privileging economic beneficial uses and raising questions of transparency. We fill a theoretical gap by building informal institutions into the HI framework as significant in both challenging and maintaining the "logic" of the system of water rights. We look below the surface of court cases brought against OG water right holders to examine the Colorado case. We demonstrate how a history of conflictual relationships has generated a contemporary political divide between east and west Colorado, an ongoing relational exchange that creates and remakes the institution of water rights in Colorado. The relationality between institutions and contexts is explained throughout the paper. We encourage future studies to empirically test our theoretical contributions to the HI framework.

Historical Institutionalism for Natural Resource Institutions

Tracing Institutional Change and Continuity: A theoretical and methodological framework

HI scholars trace how past political decisions at the local, state and federal level shape contemporary practices, policy and institutional outcomes (Steinmo 2008; Pierson and Skocpol

2002; Amenta 2012). The HI methodology has been used to analyze large scale national and international comparative social policy and political regime change (Mahoney & Rueschemeyer 2003). Research examines large scale outcomes such as revolutions (Skocpol 1979; Goldstone 2003), democratization (Mahoney 2003), emergence of capitalist agriculture in England (Brenner 1985), and state formation and regime change (Anderson 1974; Tilly 1975). Comparative studies examine how opposing political parties attempted to deconstruct established social programs (Pierson 1995), prevent or slow initial adoption of social policies in the U.S and Britain (Amenta et al.1998), and comparative national health insurance configurations based on private or public healthcare provisions in Britain, Canada and the U.S. (Hacker 1999; 2004). However, the HI framework has scarcely been considered in terms of natural resource institutions (Froger and Méral 2012; Hotimsky et al. 2006; Montpetit 2002).

The HI methodological framework is comprised of path dependencies, critical junctures, policy feedbacks, and analysis through cross-case comparison (Figure 1). Path dependency suggests that small events have long-term effects and consequences by reinforcing normative, predictable routes of social behavior and policy (Arthur 1989; Thelen 1999; Mahoney 2000). Path dependencies explain the reproduction effects of critical junctures. These junctures are moments that initiate significant change in a short period of time by offering a previously unavailable range of choices to actors (Cappocia and Keleman 2008:348). Positive feedbacks reinforce existing, modified or new path dependencies until new events shape a divergent trajectory (Pierson 2004).

Gradual change occurs through institutional *conversion,* or when an institution takes on new goals and purposes, effectively redirecting its functions (Thelen 2000). An unrecognized role of informal institutions is the influence on institutional *conversion* and the attendant *layering*

where an institution adopts new functions "layered" upon the old institution (Hacker 2004; Thelen 2000). Informal rules may emerge as a component of gradual change when formal institutions are incomplete or when actors prefer, but cannot achieve, a formal institutional solution (Helmke and Levitsky 2004: 730–731). Layering and conversion thus allow for institutional reproduction to occur (Waylen 2014) such as the development of flexibility in Colorado's system of prior appropriation through both formal and informal change mechanisms.

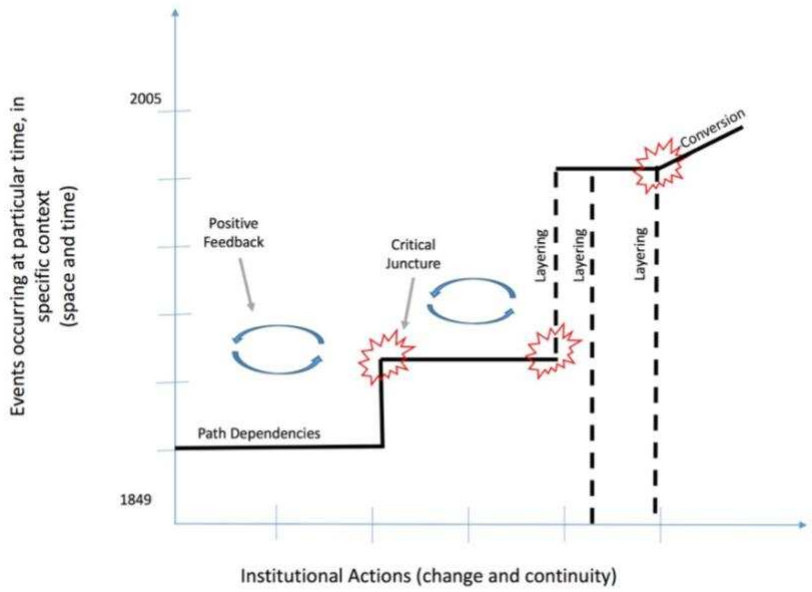

Figure 2.1: Conceptual model of the historical institutional theoretical framework identifying a trajectory of institutional continuity and change as it is relationally shaped by events over space and time. The linear representation is for comprehension purposes. Institutional actions can be thought of as reflexive and non-linear.

Examining these patterns of change and continuity across cases provides an opportunity to compare two distinct sites and improve analytic conclusions in the HI theory (Reskin 2003; Hedstrom and Swedberg 1996; Yin 2008). To trace recursive institutional continuity and change in the system of prior appropriation, history will be broken up into component parts: institutional

origins, path dependence, critical junctures, feedback loops, layering, and conversion. We examine these component parts to better understand how OG water users relationally shape institutional outcomes in Weld and Garfield Counties.

Data Collection and Analysis

Multiple data resources were collected to understand how and from where OG accesses water. Data were gathered from scholarly and government publications (Goodwin et al. 2014; EPA 2015) and a document analysis of primary source formal water court agreements including Substitute Water Supply Plans (SWSPs) and Water Right Decrees[4] was undertaken. Legal documents from government databases were collected and evaluated in three phases. First, a literature review identified strategic search terms used to locate water right decrees and short-term lease agreements (SWSPs) from the Colorado Division of Water Resources online databases Laserfiche (http://dwrweblink.state.co.us/) and HydroBase (http://water.state.co.us/DataMaps/Pages/default.aspx). Search terms fit into categories of energy company, water provider and transport names, county, industrial use, and key terms including oil and gas.

The next phase applied a Boolean search logic to locate the relevant water rights and SWSPs in the government databases between 2000-2015. This time frame includes the state's height and decline of water use for drilling activities. Boolean searches consisted of combinations of county name, energy company, water organization name, and keywords such as 'natural gas' and 'oil'. Records returned from searches were organized using a common naming

[4] SWSPs are short-term augmentation plans utilized when an individual or company has a water right application being reviewed by the water court. Water rights, or decrees, are a legal document adjudicated by the state water court that defines a user's right to put a particular amount of water from a specific location to beneficial use.

convention for database organization. Documents were analyzed using systematic coding (Cresswell 2013) for applicant and water right holder name, diversion location, appropriation date, water source, decreed use(s) and volume, and proposed new use(s). Finally, these findings were reviewed with State Division Engineers to ensure the document analysis credibly identified water sources, or water access mechanisms for OG development. (for more on validity in qualitative analysis: Lincoln and Guba 1985; Marshall and Rossman 2014).

The HI theory and methodology were then used to trace institutional change in flexibility and water access mechanisms from the beginnings of prior appropriation initiated by the Colorado Gold Rush of 1859 to present day. In the following section, we describe contemporary OG water access mechanisms identified through our analysis of water court documents.

Comparing Contemporary Oil and Gas Water Access Mechanisms in Weld and Garfield Counties

The number of active OG wells in the state has increased from 22,500 in 2002 to 54,200 in 2017 (COGCC 2017). Throughout its lifecycle, each well uses between 3 and 8 million gallons, or between 9 and 24 acre feet of water (Goodwin et al. 2014)[5]. Two of Colorado's most productive OG fields span the U.S continental divide and two different river basins: The South Platte and Colorado Rivers located in Weld and Garfield Counties respectively (see Figure 2.2). Both rivers are situated in a snowmelt dominated climate regime and the state is dependent upon that snow for adequate water supply (USBR 2012). The different water access mechanisms across the two counties represent divergent interpretations of flexibility under the same institution of prior appropriation (Table 2.1). Garfield County operators rely on conditional and

[5] For context, one acre foot will supply two average families for a year.

senior water rights, access mechanisms built into the original Colorado Constitution and modified through the 1969 Act discussed below. Weld County operators rely heavily on multi-use and short-term leasing opportunities made available through the 1969 Act and the Colorado Big Thompson project.

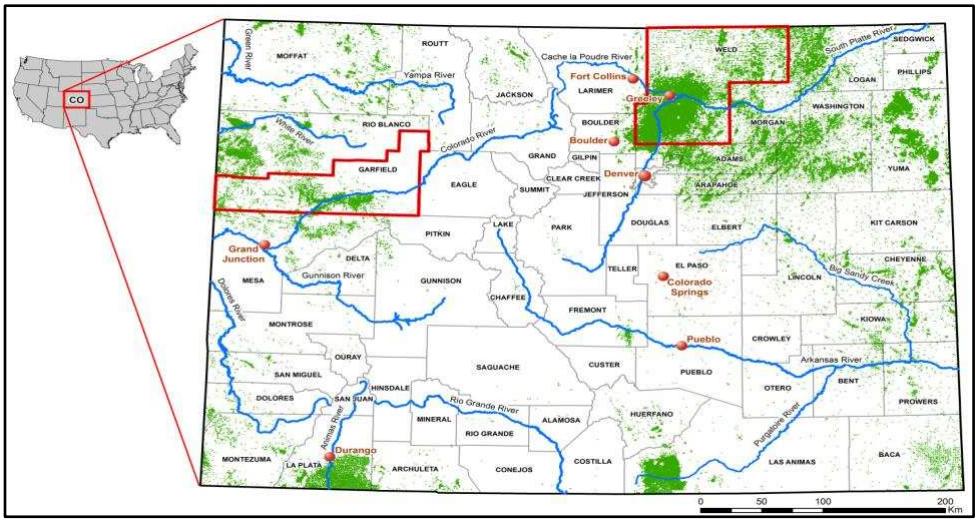

Figure 2.2: OG wells and river basins in Colorado counties. The green dots are OG wells. Garfield and Weld Counties are outlined in red.
Data Sources: Colorado Oil and Gas Conservation Commission; Colorado Department of Transportation; U.S Geological Survey

Table 2.1: Comparative Contexts and Water Sourcing Trends for OG in Weld and Garfield Counties
This table organizes the contextual variables including river basin, annual precipitation, population, and the extent of federally managed lands. The increase in OG development, related policies, water providers and access mechanisms identify the scope of OG production and water use for each region.

	River Basin	**Average Annual Precip** (inches)	**Population 2016**	**Irrigated Acres 2012**	**Percent Federally Managed Lands**	**Change in Number of OG Wells 2006 -2016**	**Federal & State Policies Enabling Water Use for OG**		**Water Providers Selling to OG Use**	**OG Water Access Mechanisms**
Weld County	South Platte River Basin (SPR)	16	269,785	831,000	13	9,640 - 23,160	Colorado's First Constitution 1876 WRDA[4] 1969	CBT Project 1937	Irrigation & reservoir companies, CBT[2] shareholders, municipalities, private water haulers Energy Companies	CBT[2], SWSP[3], Water Rights
Garfield County	Colorado River Basin (CRB)	18	57,461	310,854	60	7,463 - 11,220		Synthetic Fuels & Federal Energy Acts	Irrigators, Energy Companies	Senior and Conditional Water Rights

Source of:
population data: U.S. Census, www.census.gov/topics/population.html
precipitation data: U.S, Geological Survey, http://waterdata.usgs.gov/nwis/sw
agricultural data: US Department of Agriculture, www.agcensus.usda.gov/Publications/
Colorado oil and gas data: http://cogcc.state.co.us/library.html#/staffreports
[2]Colorado Big Thompson
[3] Substitute Water Supply Plan, short-term leasing option
[4] Water Rights and Determination Act of 1969

Weld County The South Platte River flows east of the continental divide across Colorado's Front Range, through Weld County and east to Nebraska. The river supplies the greatest concentration of irrigated agricultural lands in Colorado with 85% of water used to irrigate 831,000 total acres representing 24% of the state's irrigated acres (CWCB 2015). OG development began to surge in the early 2000's and Weld County is the top producing county with 23,160 active oil and gas wells (COGCC 2017). The South Platte is over-appropriated, meaning that in average years there are more legally sanctioned water uses than there is available water; OG operators are nevertheless able to access water for HF. According to data collected from state databases, operators and private entities including water haulers, municipalities and increasingly from stakeholder-driven irrigation and reservoir companies purchase water rights from agricultural users (Table 2.2).

Table 2.2: Example of water right cases purchasing water from irrigation use for OG development

Water Right Case Number	Quantity of water (in AF)
12CW0090	3169
08CW0065	4191
02CW0390	5065

OG operators also secure short-term leasing arrangements including SWSPs from these same private entities and pay anywhere from $300 to $3,500/af of water. This is in contrast with the $35/af paid by agricultural producers in the same region.

Water is both native to the South Platte and diverted from the Colorado River Basin through the Colorado Big Thompson (CBT) project. CBT water is diverted from Western Colorado, under the continental divide and into the South Platte. The project is operated and maintained by a public agency, Northern Colorado Water Conservancy District. Importantly,

water is designated as multi-use, meaning it can be leased to diverse use types (i.e., municipal, industrial, irrigation) without long and costly water court change of use cases.

Garfield County On the west side of the continental divide on Colorado's western slope, Garfield County is the second largest OG producing county after Weld with 11,220 active wells (COGCC 2017) and located on the main stem of the Colorado River Basin (CRB). The main stem of the CRB has 310,854 or 8% of the state's irrigated acres of farm and ranch lands (USDA 2014). OG operators lease small amounts of CRB water from private entities including ranchers and conservancy districts, own absolute (active diversions) and conditional water rights. Of significance to our study on flexibility, we focus on 'conditional' water right data collected from Colorado's Division of Water Resources Database. Conditional means the applicant has reserved a place in the priority list, has proven intent to divert the water by taking a justifiable first step toward development but does not immediately need to put the water toward a beneficial use. A conditional right holder intends to make beneficial use of the water for future development, in this case OG extraction. Every six years, conditional water right holders must demonstrate to the water court that they are making progress toward a beneficial use of the water and that the appropriation can and will be completed. This process is termed "due diligence". Once water is put to a beneficial use, the right's status shifts from conditional to absolute. Beginning in 1949, companies such as Chevron Texaco, ExxonMobil, and the Union Oil Company of California acquired conditional rights from agriculturalists in anticipation of a federally funded oil shale boom which never came to fruition.

The rights intended for oil shale development have since been sold to OG operators. Encana's diligence cases exemplify the trend in water access for OG operators in Garfield

County. Both Garfield and Weld case studies are rooted in unique contexts and histories but operate under the same system of prior appropriation.

Colorado's Prior Appropriation, a Primer

Prior appropriation is the legal structure for water allocation in Colorado and the Western U.S. There are four primary principles of Colorado's prior appropriation doctrine: Diversion, Beneficial Use, Usufractory Water Rights, and Priority. Diverted water must be continually put to a beneficial use such as municipal, industrial, and irrigation. Beneficial use refers to the use, or purpose for making an appropriation of water, often defined for economic benefit. A water right is a usufractory property right meaning that private and public entities may develop or purchase a right to use a portion of the public's water resources but cannot own the water quantities being put to beneficial use. The priority principle states 'first in time, first in right', signifying the first person to put water to a beneficial use has the right to that water at the first exclusion of others during times of shortage (Jones and Cech 2009). A priority list enforced by the state's water administration identifies the older water rights as 'senior' and the newer rights with less priority as 'junior'. In Colorado, the Division of Water Resources administrates water rights, oversees water allocation in accordance with state statutes, decrees and interstate compacts, issues use permits, monitors stream flow and water use, and manages databases storing Colorado's water use information (CDWR 2017).[6]

[6] For details on state water agencies and formal decision-making entities:
http://water.state.co.us/Home/WaterLinks/Pages/WaterRelatedStateAgencies.aspx
The Citizen's Guide to Colorado Water Law provides the basics of Colorado water law and administrative processes:
https://www.yourwatercolorado.org/cfwe-education/water-is/water-law

Institutional Origins: Transitions from gold mining to liquid gold

Tracing the origins of prior appropriation illuminates the events and circumstances that grew into a state-based water right administration system favoring economic development and anti-speculation. European settlers brought riparian law from the U.S east coast to mining camps in Colorado. The riparian doctrine grants water use only to those that own land adjoining a river or stream. However, the riparian doctrine clashed with the priority of use and beneficial use principles brought to Colorado by California gold miners in 1859. Priority of use, stating that the earliest user of a mining site wins the right to mine that site, was a key tenant of mining codes because it mitigated conflicts ignited when multiple claimants encroached on the same extraction site (Gregory Mining District Colorado 1859). Beneficial use stipulated that mining claims had to be consistently worked and water utilized to maintain rights and demonstrate anti-speculation, or that investors were not purchasing properties to sell later for profit (Schorr 2012). Riparian laws were eventually rejected in support of prior appropriation's adherence to beneficial use and the priority principle that fostered economic development and avoided speculation.

In 1860, the first "Act Concerning Irrigation" drew upon these basic rules characterized in mining laws and applied them to water used for agricultural production (Jefferson Territory 1860). Once the Gold Rush subsided and settlement in the Colorado Territory intensified, agriculture replaced mining as the region's primary water use. Mining district laws were adapted to agricultural uses and ratified in Colorado's first constitution of 1876, Article 16 titled 'Irrigation' (COL. CONST. art. XVI, §§ 5 - 8).

The institutional conditions, norms, and policies that generated the original system of mining water rights were adapted for agricultural production, maintaining the principles of prior appropriation. The principle of 'beneficial use' was consistent with mining laws limiting

speculation, the concentration of wealth, and potential monopolies in water right ownership. Farmers were particularly wary of capitalist speculation, reminiscent of the privileges afforded wealthy landowners in the Eastern U.S under the riparian doctrine that were contra to the equal opportunity and public ownership settlers sought in westward expansion (Schorr 2010). The value-based rejection of the riparian doctrine exemplifies how informal institutions have shaped institutional outcomes of prior appropriation from the beginning. Informal institutions emerge when, "adapted configurations of rules, practices, norms and relationships are attributed meaning and authority. These refurbished arrangements are the necessary responses to everyday challenges, and are embedded in daily practice" (Cleaver and de Koning 2015:4).

Historical institutional development stems from a context where owning and controlling water was open to anyone willing to put it to a beneficial use. During the institutional beginnings of the late 1800's, flexibility from augmentation plans and SWSPs was not necessary. With a basis in extractive industry values, water was developed along with Western landscapes under the banner of manifest destiny and economic prosperity (Schorr 2010). However, World War II and a sequence of federal energy policies encouraged more flexibility in prior appropriation to facilitate the movement of water from agriculture into energy development.

Relational Institutions and Change: Federal energy policy shapes flexibility in Garfield County

In 1944, President Roosevelt signed The Synthetic Fuels Act allocating $30 million over five years for synthetic-fuels research and development (Andrews 2006).[7] The Program aimed to stimulate large-scale commercial development of oil shale and other unconventional sources at a

[7] Synthetics are defined as any fuel engineered as a substitute for oil to power American's warships, airplanes, tanks and automobiles.

time when the country was focused on supplying resources for the Second World War. In the name of national security, the Act authorized the construction and operation of demonstration plants to produce synthetic fuel from oil shales (Andrews 2006). Federal Energy Laws did not stimulate energy extraction in Weld County to the extent they influenced Garfield County's federal lands which had been acquired specifically for energy development during the 1940's. The need for fuel during World War II and the supporting Synthetic Fuels Act shaped right ownership, water use, and impacted future access to this water by other users. These same rights have stayed in the hands of private energy companies in Garfield County where they are likely to remain since energy extraction is the most lucrative beneficial use.

Energy companies actively acquired water rights from irrigation uses including existing agricultural ditch rights since "acquisition of ditches provides control of water with senior priorities, especially important on the flow-limited tributaries in which they are located" (MacDonnell 2009:8). In 1949, the earliest conditional water right for oil shale development was purchased by Union Oil Company of California for 118.5 cubic feet per second (cfs). By 2009, this sequence of events led to energy companies owning part or all of 57 irrigation ditches and a total of 4,996 cfs + 736,771 af of conditional water rights throughout the CRB, concentrated in Garfield County (MacDonnell 2009). The Act's subsidies opened a window of opportunity where companies purchased a larger quantity of rights then they otherwise would have. Energy company ownership of irrigation ditches and conditional rights exemplifies institutional layering where OG beneficial uses layer atop traditional agricultural ownership and uses.

In addition, the relational interactions between federal energy and state water institutions triggered a critical juncture in the historical trajectory of water access mechanisms for OG operators in Garfield County. This critical juncture launched the dynamic path-dependent

process of OG companies owning conditional water rights in Garfield County, narrowing the probability for other possible trajectories flexibility in water access mechanisms could have taken. That is, OG company choices to purchase water rights had more influence on engraining a *particular type* of flexibility within prior appropriation relative to their power before and after Synthetic Fuels Act implementation (Capoccia and Keleman 2007). The federal and state institutional interactions increased the probability that future water use would follow the same institutionalized trajectory of OG water use and conditional right ownership, shaping water rights and participating in a type of flexibility that favors economically lucrative uses in the system of prior appropriation.

Increasing Flexibility: Privileging Economic Beneficial Uses and Questions of Transparency

The Colorado 1969 Water Rights Determination and Administration Act built more flexibility into the system of prior appropriation and further enabled OG development in Weld County. The Act increased flexibility by expanding water access mechanisms to include multiple and short-term uses through two provisions: augmentation plans and temporary leasing through Substitute Water Supply Plans (SWSPs). Augmentation plans and SWSPs legally allow for new water diversions without long, costly right change cases. This flexibility created through the 1969 Act allowed private water transporters, natural resource companies, municipalities, stakeholder-driven irrigation and reservoir companies in Weld County to increase sales to OG between 2000-2015. OG companies paid between $300 to $3,500/af of water. This is in contrast with the $35/af paid by agricultural producers in the same region.

Both the 1969 Act and the CBT project operate under state administration but CBT water

is imported from a different river basin (Colorado River in western Colorado) into the South Platte, freeing water administration from many of the requisite constraints and securities experienced under prior appropriation principles. First, since CBT water is designated as multi-use it can be leased to diverse use types without long and costly water court change of use cases. Second, 100% of CBT water can be consumed without concern for downstream users. Thus, while CBT water use technically operates within the state's system of prior appropriation, its diversion from a different basin of origin negates the need for the protections for downstream users. This circumstance frees the CBT project to operate as a water market that does not answer to the principles of beneficial use and priority, a meaningful difference from native South Platte River water tied to prior appropriation principles. In Weld, CBT multi-use water is a crucial source for OG development. CBT water is leased to diverse use types offering a short-term supply that fits changing energy markets. The CBT allocation system has evolved into the most active and "successful" water market in the US West in terms of number of trades per year (Liebcap 2010).

Holding a magnifying lens over OG extraction water access mechanisms confirms the trend toward multi and short-term water use on the eastern plains and the corresponding shifting nature of flexibility in prior appropriation. CBT water markets and the 1969 Act signify a transformation in the goals and purposes of prior appropriation. They intersect to reproduce processes of gradual conversion that increase flexibility, a function not accounted for in the original institutional design. As an outcome of these changes, multi-use water does not require specification of quantities by use type. Without such accounting, tracing water sourcing and quantities in Weld County is increasingly less transparent.

Multiple use water is sold to the highest bidder, a standard written into the Colorado constitution under the beneficial use principle. However, the social and institutional contexts have changed and CBT shares now cost $30,000/ af, a price that challenges prior appropriations foundations in a wide distribution of rights, serving diverse water right holders and regulating speculatory control of water resources (Schorr 2012). While increased flexibility makes multiple uses easier, it also favors the most economically lucrative uses and generates issues of transparency in water use, an important consideration for the public's resource.

Reinforcing Institutional Trajectories: Water Access Mechanisms through Positive Feedbacks (Federal Policy and Garfield County)

Federal energy policies continue to influence Colorado water right institutions. In 1949, Haliburton was granted exclusive license for HF technology, reinforcing energy company need for flexible water access. In the late 1960's and early 1970's, the U.S. Department of Energy supported the Western Gas Sands Project that brought HF research and technology to Western Colorado (DOE 2012).

In 1973, the Organization of Arab Petroleum Exporting Companies (OPEC) oil embargo prompted President Richard Nixon to outline Project Independence, a plan to free the nation from foreign energy sources by the end of the decade. By 1974, interest in domestic energy sources surged and the Interior sold off six federally owned tracts of land for energy development, two each in Colorado, Utah, and Wyoming of more than 5000 acres apiece (Hanson and Limerick 2009).

The 1979 Iranian Revolution accelerated fears about uncertainty in access to foreign oil supplies when OPEC increased prices on petroleum. By the 1980s, federal policies focused on

nationalizing energy production and supported oil shale development and the dissemination of HF technologies. The 1980 Energy Security Act signed by President Jimmy Carter aimed "to improve the Nation's balance of payments, reduce the threat of economic disruption from oil supply interruptions...". An important difference between this and the Synthetic Fuels Act of 1944 was that this Act offered public subsidies to private developers of commercial synthetic fuel plants to further incentivize fuel development.

The Energy Security Act gave the economic boost companies such as Exxon, Chevron, Union Oil and Conoco needed to explore Colorado's western slope. The Act appropriated $2.6 billion for three synthetic fuels projects, two of which were in Garfield County and combined became known as the Colony Project (Title I, Part B of the Energy Security Act of 1980). The projected scale and production included six of the world's largest open pit mines that produced eight million barrels of oil a day by 2010 (Hanson and Limerick 2009). The Colony Project was exemplary of the renewed drive for a reliable national energy source and the role of the federal government in subsidizing oil shale for this purpose. However, by 1982 expectations of national energy security dropped with prices for foreign gasoline and Union and Exxon-Tosco pulled out of the Colony Oil Shale Project. These projects advanced technological developments while also further engraining water use for energy production in Garfield County.

While Garfield County experienced energy development throughout the 1990's, the next relevant energy legislation was The Energy Policy Act of 2005. The Act reinforced the positive feedback loop for HF technologies and its required water use by effectively exempting fluids used in HF from protections under the Clean Air Act (1970), Clean Water Act (1972), Safe Drinking Water Act (1974), and the Comprehensive Environmental Response, Compensation, and Liability Act (1980) (Kosnik 2007). The Energy Policy Act excused companies from

disclosing the chemicals involved in HF operations that would normally be required under federal clean water laws. The loophole is commonly known as the "Halliburton loophole" since former Halliburton CEO and Vice President Dick Cheney was reportedly instrumental in its passage (Kosnik 2007).

The sequence of events including public-private partnerships to develop extractive technologies, the contextual political events including the OPEC oil embargo and the Iranian Revolution combined with the 1980 and 2005 federal Energy Acts reproduced the trajectory set forth by the 1944 SFA through a positive feedback of water use for energy development and conditional rights as flexibility in Garfield County. Although oil shale was not developed on a commercial scale, OG companies employing the more economically viable HF technologies have bought and sold conditional water rights originally acquired for oil shale. For example, after the absolute discontinuation of oil shale extraction in the early 1990's, Encana Oil and Gas purchased Union Oil Company of California's original 1949 conditional right.

The intersecting institutions of prior appropriation and federal energy development policies including the SFA events channeled resources and infrastructure to Garfield County, precipitating divergent water right configurations and types of flexibility in Weld and Garfield Counties (refer to Table 1). The loophole created in the Energy Policy Act in conjunction with federal subsidies secured the institutional support and framework to insure continued development of oil shale and HF technologies while unintentionally shaping water right ownership on the CRB for decades to come. In this way, water and energy institutions are relational so that interactions between them are a source of both institutional continuity and change.

Improving the HI Framework: Blending Formal and Informal Institutions

Historical institutionalists define institutions as "emergent, higher-order factors above the individual level that influence political processes and outcomes and tend to produce regular patterns or stasis" (Armenta 2012). We add that informal, bottom up institution making has been critical to understanding continuity and change in the system of prior appropriation but is not accounted for in the HI framework. Informal institutions are nuanced norms, decision-making structures, unwritten rules and activities that shape and are shaped by agent's lived experiences. These informal dealings are consistently negotiated day-by-day, are not defined in formal laws, policies or organizational documents but help explain formal institutional change and actual policy outcomes. For example, gender relations, power struggles and stereotypes shape actual on-the-ground policy outcomes. Informal institutions are acted out and must be accounted for in tandem with formal institutions as they fill gaps and resolve ambiguities of formal rules, one relationally shaping the other (Waylen 2014). As such, prior appropriation is embedded in complex social relations where actor decision-making recursively interacts with changing institutional structures and political divisions (Mehta et al. 2001; Evans 2012; Cleaver 2012). The remainder of this section details examples of informal institutions operating below the surface of formal institutions and how they shape agent choices on the ground.

Beginning with the value-based rejection of the riparian doctrine, equal opportunity and public ownership values discussed above, these informal institutions relationally shape formal policy. Daily interactions of farmers talking to farmers, irrigation district collaborative decision-making processes, neighboring ditches negotiating informal water sharing so there are less transaction costs at the administrative levels, and even handshake agreements have occurred 'below the surface,' in tandem with policy activities at the state level.

For example, Colorado water law requires a rancher to bring water exchange cases to water court, even if he/she wants only to swap water with a wheat farmer two parcels down the road. Since producers are experienced water managers, know approximately who irrigates when and about how much water is needed on which crops, the rancher-farmer neighbors can schedule a time, quantity, and location of diversion to exchange water between the two producers without causing harm to downstream users. They have then effectively saved time, money and paperwork through negotiating a handshake deal. A Weld County farmer describes how informal institutions use to facilitate more effective water management in agricultural communities:

> "… farmers would lease water to each other so if you and I were farming and you ran a little short I have some extra I could get you and maybe what I have isn't enough to cover your needs but with 2 or 3 other guys it could and then maybe a different year you have excess and I'm short and we used trade back and forth like that all the time."

Garfield County producers shared a similar experience:

> "… as far as administration, it has gotten a lot more strict and by the book. Forty years ago things were run more, a little looser…a lot more water trading … handshake agreements between farmers, I could use your water this week and you could use mine next week, which made a lot of sense. As time has progressed the state engineer has gotten more strict about doing things by the book and I think their hands have been forced a little bit."

Informal arrangements such as these became a driver in tightening the informal flexibility taking place under the surface of formal state water policy and continues to impact Colorado water use and management.

In addition to driving reactive formal policies, attending to historic political divides helps explain formal legal outcomes of water law in the late 1990's and early 2000's. On Colorado's west slope, conditional water rights were challenged through multiple Supreme Court Cases brought against energy companies. The CBT managing entity, Northern Colorado Water

Conservancy District, alleged that some of the largest OG operators on the west slope: Chevron, Getty Oil Exploration Company, and OXY were not exercising due diligence (proving sufficient intent to develop the resource), on their conditional rights. They charged that the anti-speculation doctrine should be applied and that poor economic conditions could no longer be used as an argument for lack of water use or development (see 990 P.2d 701 Colo. 1999, Mun. Subdist., N. CO Water Conservancy v. Oxy Usa, Inc.; 986 P.2d 918 Colo. 1999, Mun. Subdistrict, N. CO Water v. Chevron hale Oil Co.; 997 P.2d 557 Colo. 2000, Municipal Subdistrict v. Getty Oil Exploration Co.). The OG companies ultimately won the case and maintained their conditional rights, the same rights many companies still hold.

The formal court rulings veil the often-overlooked informal institutions that continuously make and re-make a prior appropriation embedded in complex social relations where actor decision-making recursively interacts with changing institutional structures and political divisions (Mehta et al. 2001; Evans 2012; Cleaver 2012). Western slope water users worry that releasing conditional rights from OG company ownership will permit for transmountain diversions under the continental divide to the Front Range in the east (CWCB 2015). Garfield County water users and their institutions are under consistent pressure to allow more water from the CRB to Front Range urban use where 87 percent of the population resides. Although legal under prior appropriation, diverting more water from the Colorado River compounded with CBT water use would stifle future economic development, challenge low flow requirements for endangered fish populations, and further put stress on water managers to meet interstate compact obligations (CWCB 2015). Original CBT project agreements include provisions to prioritize water for western over eastern slope appropriations to avoid conflicts (S.D. 80 Section 5 (c) page 4). However, the highly political CBT project process ended with numerous broken promises to

western slope residents and more water flowing to the Front Range than was originally collaboratively and legally agreed upon (Tyler 1992). Out of this political divide, the Colorado River District was formed during CBT negotiations in 1937 and charged with the sole mission of protecting west slope water rights for future economic development. In this way, western slope water users deliberately fostered change by drawing on a combination of formal institutional rules, local knowledge and regional relationships.

The political divide between east and west Colorado nevertheless dynamically stabilizes the path dependency that began back in the 1940's with the Synthetic Fuels Act and acquisition of conditional water rights. As long as west slope right holders resist pressures to sell to Front Range water providers, they effectively reproduce conditional water rights as a type of flexibility through positive feedbacks.

Conclusion

Prior appropriation is a fundamentally dynamic process characterized by variable levels of institutional visibility and functioning. The nature of institutional interactions feed informal institutions and invite different types of institutional transitions and trajectories. We miss the significance of these arrangements when aiming for an institutional analysis that obscures underlying political conflicts and informal dealings taking place 'under the surface'. To illuminate these points, we have held a magnifying glass over the historical development, continuity, and outcomes of institutional flexibility in Colorado's water right system.

The HI theoretical and methodological framework highlights how flexibility is enacted and reproduced over time. Divergent historical and political trajectories in the two counties have shaped a flexibility that favors conditional rights in Garfield and multi-use water rights/CBT in

Weld County. The ordering of historic critical junctures and path dependent political processes perpetuated by feedback loop reproduction have developed and maintained a particular practice of flexibility favoring the most lucrative uses. Institutional change and continuity relies on the subtle complexity of gradual layering demonstrated with OG as a new water use in Garfield County. Conversion through the Water Rights Determination Act and CBT water markets redirected institutional functioning toward more flexible, multiple uses. Contextual circumstances including the timing of legislation, relational federal and state policy processes, and local informal institution-making in large part explains the differences in water access mechanisms and types of flexibility between counties. The ability of companies to obtain water relies on a particular type of flexibility that privileges economically lucrative beneficial uses.

Prior appropriation was written into Colorado's constitution at a time when rivers were barely appropriated and settlers focused on economic development. The beneficial use requirement adapted from mining codes was originally important in limiting property rights and speculation so that economically poor farmers would be guaranteed access to water for food production (Schorr 2012). Colorado water governance has been and is responsive to industry needs and pressures in a desire to remain economically viable and respond to market demands. Multi-use decrees and market-based allocation systems such as the CBT allow for fewer transaction costs, providing an answer to water policy and governance research arguing for the creation of flexible institutions for climate change adaptation (Folke et al. 2005; Pahl-Wostl 2012; Gallaher et al. 2013).

However, the laws and administration of prior appropriation are what make the system flexible for *all* users. Water rights are unique since they are tied to a particular use. When detached from the use in multi-use decrees or through the CBT market, we have less knowledge,

transparency and accountability of where water goes and if water is going toward a public good. In recent years, flexibility in Colorado water policy has been proposed through various FLEX bills aiming to modernize the system of prior appropriation (HB13-1248, HB14-1026, HB15-1038). The expected doubling of state population over the next 30 years will result in continued urbanization of farmlands and transference of water rights to municipal and industrial uses. Currently agricultural users hold 75% of water rights (CWCB 2015). While farmers struggle to maintain these rights under increasing urbanization and pressure to sell to municipalities, new users developing OG resources have managed to access existing flexibility. Water policy will continue to adapt toward more flexible access, we call for more explicit institutional support to assess the social and environmental impacts of these changes.

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CHAPTER 3

WATERING COLORADO'S OIL PATCH: AGRICULTURAL WATER ACCESS AND EQUITY

Colorado's Division of Water Resources considers water use for oil and gas (OG) extraction activities as short-term and an insignificant percentage of Colorado's overall water consumption (Rein and Wind 2015). There is additionally no mention of concern about long-term OG water use impacts to rural communities in the Statewide Water Supply Plan[8] (CWCB 2015). OG activities are not represented at the Basin Roundtables, a state initiated water governance mechanism mandated to integrate bottom-up, local decision-making into the State's Water Plan. These are the predominant entities responsible for guiding water policy in the state. While Colorado's institutions were built on the premise of mining interests, the contemporary pace and scale of energy extraction represents a new phenomenon that has not been critically examined. The number of active OG wells in the state has gone from 22,500 in 2002 to 54,200 in 2017 (COGCC 2017). Throughout its lifecycle, each well uses between 3 and 8 million gallons, or between 9 and 24 acre feet (af) of water (Goodwin et al. 2014)[9]. We ask if agricultural water users are experiencing changes in water access related to increased water use for OG development and examine the implications of these changes.

OG companies are part of a larger trend characterized by municipal and industrial water users purchasing water out of agricultural, challenging the viability of Colorado's agricultural production (CAWA 2014), and further reducing long-term economic options for rural communities. Addressing the specifics of municipal water transfers is out of the scope of this

[8] The state is charged with researching and developing the Statewide Water Supply Plan that addresses the potentially increasing supply gap of 500,000 acre feet. This plan will guide the future priorities and allocation of Colorado's water.
[9] One acre-foot (AF) is equal to 325,851 gallons and is approximately the amount of water used by 2 families in a year.

paper and covered extensively elsewhere (Brewer 2007; Eden et al. 2008; MacDonnell and Rice 2008; CWC 2005; Doherty et al. 2012; Pease 2012). Instead, we focus on how increased OG water use shapes agricultural water access through the important and changing role of agricultural water supply organizations (AWSOs), including producer-run irrigation, ditch, and reservoir companies. AWSOs administer approximately 75% of the state's water supplies (CWCB 2015) and play an important role in leasing and selling water to OG operations. When OG developers purchase water rights, they become members and shareholders in previously agricultural-dominated AWSOs. With OG purchasing more shares in irrigation, reservoir and ditch companies, they will have more decision-making within these organizations. Short-term, usually between one and seven years, leasing arrangements entail AWSOs taking on the role of water manager and allocator for a non-agricultural use. OG purchasing AWSO shares and the short-term leasing agreements collectively indicate industry's integration into rural water organizations and decision-making. Water access for ag users ultimately decreases while the benefits of energy production and extractive water uses migrate out of rural communities.

Several themes emerged from interview data that highlight how increased water use for OG shapes AWSO activities and water access for farmers and ranchers. We interviewed 42 respondents from diverse water user groups in Colorado to find that in some cases, water use for OG development reinforces agricultural water use. Producers (including ranchers and farmers) and their water supply organizations enter into short-term water leasing agreements with OG companies that generates a new, relatively low risk revenue stream. AWSOs use the income on irrigation infrastructure improvements, to pay off loans as well as pay annual membership administrative fees, or 'assessments' that producer members would otherwise be responsible for

paying. In these ways, OG activities contribute to farmers and ranchers maintaining water access and ownership through AWSO's administration and management of water.

Paradoxically, interviews reveal that energy companies contribute to decreasing and differential water access for agricultural users when they purchase water rights. Companies buy up land and water, contributing to increasing regional land and water prices, challenging access for agriculturalists. Differential access is identified in interview data when ag water user's ability to access water is appropriated by another user group with greater economic and political decision-making. This results in decreasing access to water rights, short-term leases, and water quantities. In addition, producers associate the increasing costs of land and water, in part, to OG's ability to pay more for resources. In some cases, OG users are out-competing agricultural (ag) users for access in water markets. In the context of decreasing and differential access, we also find that AWSOs in both Garfield and Weld Counties balance equity in and maintain access to water for agricultural users.

Comparing producer water access across Weld and Garfield Counties, the top OG-producing counties in Colorado, illuminates diverse experiences related to OG development. In Weld County, AWSOs that lease water to OG recursively shape new opportunities for farmers' including improvements to irrigation and water storage infrastructure. In contrast, Garfield County AWSOs are working with water tied to the land due to historic Bureau of Reclamation contracts where water must remain in agriculture. The possibility of selling or leasing in these cases is null. However, OG companies bought up water rights from non-bureau ag water users beginning in 1949 and have maintained these rights including the ranches and farm land sold with the water (Boone and Laituri 2017). While these two counties on different sides of the

Continental Divide, with different histories and river basins (see Figure 1), AWSOs in both counties are similarly working to balance equity in access for agricultural (ag) water users.

Interviews were conducted in 2015 when Colorado was in the process of developing it's first state water plan. Agriculturalists across the state were deeply concerned about water transfers out of irrigation and into municipal uses. An alliance of agricultural leaders from across the state, Colorado Agricultural Water Alliance (CAWA), worked for months to draft a statement of the ag community's goals, objectives, and needs to include in the state's larger water plan document. Participants that represent farmers and ranchers across the state pleaded for a renaming of a chapter to Agricultural Water Security instead of the name focusing on transfers out of ag use (CAWA 2014). CAWA's statement did not mention concern about water transfers for OG uses. Companies pay as much as $3,500 per af compared to irrigation users that pay between $34 and $50/af. Even as producer-led AWSOs benefit from selling and leasing water, making improvements to ag operations, there will still be some water right holders that sell to OG and retire, removing the water from ag for the foreseeable future and shaping AWSO activities toward other uses.

The remainder of the paper is organized by themes that emerged in interview data. We offer a brief primer on OG development and Colorado's water administration, the system of prior appropriation. We then describe the qualitative interview methods and analysis used to gather data followed by a section on each of the following themes: Decreasing and differential water access for producers, Leasing land and water from municipal and industrial users, Maintaining agricultural water rights, and Balancing equity in water access. Within each theme, we address interview data from Weld and Garfield Counties (see figure 3.1) but as will become apparent,

some themes are more relevant to one county or the other. I use pseudonyms throughout the paper to protect respondent anonymity.

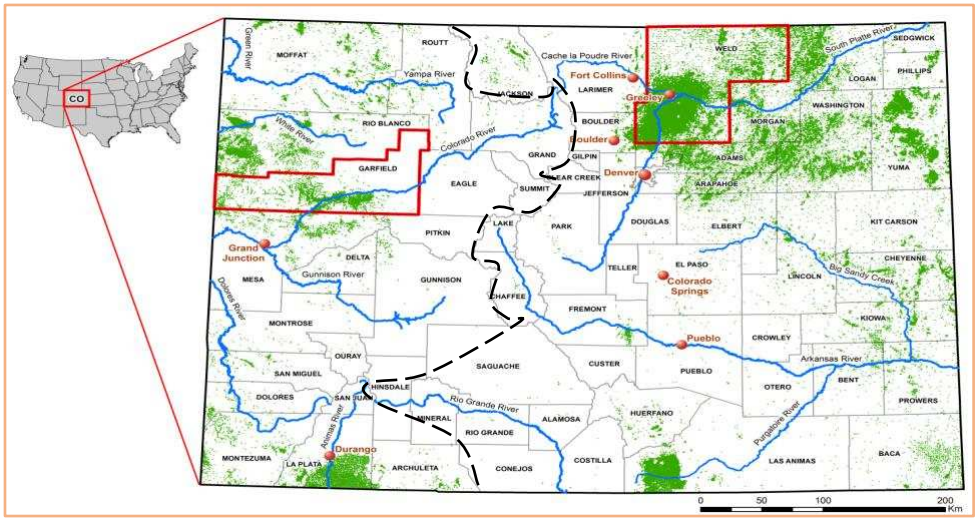

Figure 3.1: OG wells and river basins in Colorado counties. The green dots are OG wells. Garfield and Weld Counties are outlined in red and the Continental Divide is identified with a dashed black line.
Data Sources: Colorado Oil and Gas Conservation Commission; Colorado Department of Transportation; U.S Geological Survey

Primer on oil and gas development and Colorado's system of prior appropriation

The four principles of prior appropriation define the administrative structure for water allocation Colorado and the Western U.S. Diversion: Beneficial Use, Usufractory Water Rights, and Priority. Diverted water must be continually put to a beneficial use such as municipal, industrial, and irrigation. Beneficial use refers to the use, or purpose for making an appropriation of water, often defined for economic benefit. A water right is a usufractory property right meaning that private and public entities may develop or purchase a right to use a portion of the public's water resources but cannot own the water quantities being put to beneficial use. The priority principle states 'first in time, first in right', signifying the first person to put water to a beneficial use has the right to that water at the first exclusion of others during times of shortage

(Jones and Cech 2009). A priority list enforced by the state's water administration identifies the older water rights as 'senior' and the newer rights with less priority as 'junior'. In Colorado, the Division of Water Resources oversees water allocation in accordance with state statutes, issues use permits, monitors stream flow and water use administration (CDWR 2017).[10]

OG development occurs through a hydraulic fracturing process where a horizontal well is drilled approximately 5000 feet deep into the earth's surface, hydraulic fracturing injects a mixture of water, sand and a combination of different chemicals into a targeted OG bearing formation. Extremely high water injection pressures cause the rock to fracture and release oil and gas (API 2009). The process of hydraulic fracturing is referred to colloquially as 'fracking' or 'frack job'.

Methods

This study utilizes qualitative interview methods to gain a better understanding of local definitions, perceptions and behaviors on my core topics of ag water use and OG development. Utilizing a qualitative approach in this way "vividly color(s) in the meanings, motivations, and details of what quantitative research can convey only in broader aggregates" (Ambert, Adler, Adler, and Dettzner 1995:885). Semi-structured interviews focus "on how people perceive their worlds and how they interpret their experiences" (Rubin and Rubin 2012:3) in order "to learn about how and why people behave, think, and making meaning as they do" (Ambert, Adler, Adler, and Dettzner 1995:880). Semi-structured interviewing is one way to develop context and richness of data. By piecing together interviews of individual's experiences, I examine complex

[10] For details on state water agencies and formal decision-making entities:
Http://water.state.co.us/Home/WaterLinks/Pages/WaterRelatedStateAgencies.aspx
The Citizen's Guide to Colorado Water Law provides the basics of Colorado water law and administrative processes:
https://www.yourwatercolorado.org/cfwe-education/water-is/water-law

social processes and changes through uncovering multiple perspectives (Rubin and Rubin 2012:3) about the changes of water rights and differential access with increased OG activity. To facilitate this method, I developed an interview protocol, guide, and data recording system. (Refer to interview guides in Appendix B.)

The appropriate sample size became obvious as the study progressed and new topics and respondent explanations stopped emerging during interviews, or data saturation occurred (Marshall 1996). I used a combination of purposive and snowball sampling (Biernacki and Waldorf 1981; Noy 2008). The sampling frame included people knowledgeable on the topic and questioning was restricted to what they knew firsthand to improve accuracy and credibility of the study (Rubin and Rubin 2012). Data richness was achieved by including interviewees representing complementary, overlapping and contradictorily viewpoints, helping to answer not only what happens but how and why (Rubin and Rubin 2012).

We interviewed a total of 42 respondents from diverse water user groups in Colorado including farmers, ranchers (collectively referred to as producers), conservancy district managers, irrigation company and district members (AWSOs), state water administrators, water lawyers, and OG industry representatives. Of these, 20 interviews were conducted in Weld and 22 interviews in Garfield County. Table 3.1 delineates the sample frame, how many respondents in each water user group were interviewed.

Table 3.1: Interview sampling frame for Weld and Garfield Counties

County	Producer	State Admin	Lawyers	Conservancy District	Irrigation Co/Dist	OG Industry
Weld	9	3	2	0	5	1
Garfield	8	3	2	3	5	2

Once the interviews were complete, they were transcribed and word docs were uploaded into NVivo 11.4 for Mac. The analysis process followed coding, memo-writing, and analysis procedures from Grounded Theory qualitative analysis (Charmaz 2010). (Figure 3.2)

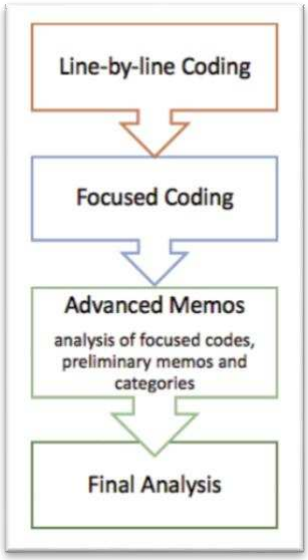

Figure 3.2: Interview Analysis Process

Using NVivo 11.4, the coding process began with line-by-line followed by focused coding procedures. The first step of line-by-line coding entails descriptively naming each line of the written data, or coding every line by asking: What processes are at issue here? How can I define it? How does this process develop? When, why, and how does the process change? (Glaser 1978; Charmaz 2010). We purposively sampled exemplary interviews insuring to represent each different user group in each county (Table 3.1) and began line-by-line coding. Line-by-line coding of every interview was unnecessary since we were reaching saturation in those interviews sampled.

The second step began with a refining of the line-by-line codes into focused codes. The goal of the focused coding was to take both the analytically chosen and most frequent line-by-

line codes and synthesize them into focused codes through an iterative analysis process. Focused codes with a higher number of line-by-line codes from a higher number of interview respondents were considered more credible then those with fewer line-by-line codes from fewer respondents (Whittemore, Chase and Mandle 2001). For example, the code 'prioritizing water for agriculture' surfaced 28 times form 15 different respondents making it an excellent candidate for a focused code. In contrast, 'regulating a new water use' was mentioned 13 times by a single respondent so was not considered as relevant.

We took into account which codes made the most analytic sense (Charmaz 2010). The code 'valuing community_choosing not to lease' included responses from only two respondents but stood out as a negative case, unique for its difference from the majority of respondents. It still had analytic value for understanding how water access for producers is changing with a new use. I regularly (after every 3-5 interviews) exported a codes list (code book) that included the number of references under each code and the number of respondents attached to those references. This allowed me to track the evolution of codes and themes as I went through the interviews.

After developing focused codes, for step three I organized them into folders in NVIVO and began the process of advanced memo writing, building on preliminary memos I had previously written. The memo-writing process involved an iterative analysis between preliminary memos, focused codes, emerging analytic categories and composed the foundation of my analysis. Analytic categories are a conceptual container filled with common themes, patterns, and comparisons of multiple codes. We then analytically grouped codes into categories, maintaining data integrity by including raw data in the memos to describe the categories, its

properties and characteristics. The resulting memos were refined to serve as the following analysis.

Findings and Analysis

Decreasing and differential water access for agricultural producers

Differential access is identified in interview data when one user group's ability to access water is appropriated by another user group with greater economic and political decision-making. This results in decreasing access to water rights, leases, and water quantities. For example, agricultural water users are unable to secure water when OG companies outbid them in water markets. Access to water becomes limited and shapes the future of farming by limiting opportunities for new agriculturalists to secure water. This theme surfaced in both Weld and Garfield County interviews but in distinct ways. Beginning in the late 1940's, consecutive oil shale booms in Garfield spurred companies to purchase water and land was out of agriculture. In addition to OG users, the Garfield County municipal water supplier has been the largest purchaser of ag land and water since the 1990s and is seen as a bigger threat to water access than OG development. In Weld County, ag water users shared their experiences of being outcompete by OG water users.

Weld County In Weld, ag water users are experiencing the rising costs for leasing and purchasing water. Exemplary of differential access, farmers cannot compete with OG's economic and political strength and farmers are priced out by industry. One irrigation company employee commented,

> "I used to lease a lot of water for farming … my contacts will tell me that the oil patch called them. The oil patch will pay three times as much as a farmer can… all the way up to 10 times, I've seen 10 times what a farmer can afford. These

> entities that are renting have always rented to farmers because that was their market before this boom and now the oil patch people come around and you can't rent from..." (10_Weld).

When asking a producer in Weld County if he has noticed any changes in pricing or leasing values of water, he responded,

> "absolutely, we do see that. Colorado water plan tries to address these issues but when it comes to economics there's some industries that are just going to keep losing out and farming being one of them because they barely make money anyway. The economics are such that the cities and the industry like gas, can pretty much outbid anybody for water." (11_Weld)

Respondents emphasized the competition for water between OG for agriculture in the Colorado Big Thompson (CBT) project. CBT water is diverted from the Colorado River in Western Colorado, under the continental divide and into the South Platte in Weld County. Water is allocated through a market-based system where shares of water can be bought and sold. The market system is more flexible for users since it is designated as multi-use, meaning it can be leased to diverse use types (i.e., municipal, industrial, irrigation) without costly water court cases. CBT water is leased to diverse use types offering a short-term supply that fits changing energy markets, providing a crucial water source for OG development. The CBT allocation system has evolved into the most active and "successful" water market in the US West in terms of number of trades per year (Liebcap 2010).

CBT water potentially offers ag users a relatively cost accessible option for leasing water through its regional pool market but this is also where most competition occurs. A Weld County rancher explained that the regional pool rents out surplus water from the previous year through a sealed bid process. In direct, unregulated competition, industry easily outbids ag users on an acre foot of CBT water. When OG industry puts in a bid, they over-bid to insure they secure the water in contrast to ag users that try to determine how low they can bid to continue to secure access.

> "... they wanted to make sure they had the water so they may have bid $200 an acre foot so if there were any holders of CBT water who were entertaining the idea of leasing, that $200 if they didn't get it they said well in must be worth more than $50 so they would say minimum bid if you want my water is $75 so that's the part that we have seen." (3_Weld)

The regional pool market was originally intended to provide cheaper water access but over time competition has increased the cost of "cheaper" water as well. Farmers have relied on the regional pool to continue farming when they are short water due to draught or insufficient water rights. One Weld County AWSO leases water regularly to make up their 8,000 af shortage that their member producers rely on. The respondent noted that the cost of water further increases and access decreases with drought and higher OG activity, "as CBT water becomes less available in a dry year, obviously it's more of an issue for us" (3_Weld).

Given that food producers are performing a public service in supplying the nation with necessary subsistence, does it make sense to have the producers in direct and unregulated competition with OG industry for water? In Weld County, CBT regional pool markets privilege industry over local producers, decreasing access for ag water users.

> "...farmers often, just because of the nature of farming, may not have a lot of money at least to throw at that problem where somebody like oil and gas or even a municipality, they can spread a big expense over a lot of different people..." (2_Weld).

In addition, how do market transactions shape the social fabric of rural communities? Transferring water out of agriculture and into municipal uses was a concern for Weld County farmers prior to the emerging OG boom in 2000. OG represents yet another challenge to ag water. When a farmer sells his or her water rights out of irrigation and to OG, the consequence is a domino effect in agricultural communities. Once farmers sell their water and stop crop or cattle production, the businesses that surround and depend on local farmers are not as stable. Once the seed and supply store closes due to lack of customers, other farmers are burdened to travel

farther distances and pay more for supplies (cite). Trading water with neighbors is not as attractive when neighbors can make more cash leasing to OG:

> "It used to be farmers would lease water to each other so if you and I were farming and you ran a little short I have some extra I could get you and maybe what I have isn't enough to cover your needs but with 2 or 3 other guys it could and then maybe a different year you have excess and I'm short and we used trade back and forth like that all the time" (1_Weld).

The farmer stated that the neighbors lease water to OG and it is no longer available for ag users. In these ways, the social fabric that binds communities together is being shaped by new water use in Weld County.

Garfield County Garfield County water users are not currently experiencing demand for large quantities of OG water. The region's transfers out of ag began in 1949 when the earliest water right for oil shale development was purchased by Union Oil Company of California (MacDonnell 2009; Boone and Laituri 2017). By 2009 energy companies owned part or all of 57 irrigation ditches and a total of 4,996 cubic feet per second (cfs) + 736,771 af of water rights throughout the CRB, concentrated in Garfield County (MacDonnell 2009; Boone and Laituri 2017).

Energy companies acquired water rights from irrigation uses including existing agricultural ditch rights since "acquisition of ditches provides control of water with senior priorities, especially important on the flow-limited tributaries in which they are located" (MacDonnell 2009:8 in Boone and Laituri 2017). In addition, there tends to be excess water in the Colorado River on average years (USBR 2012). The quantity of water needed in Garfield County OG production activities is less than in Weld since the formation is "wet", or contains water that can be pulled up from the formation and used to frack (16_Garf).

West Slope producers are more concerned with water being transferred to municipalities than to OG water use. The municipal water provider, Ute Water Conservancy District, has bought up land and water from ag users. This has raised prices of both land and water since a municipality can pay more per af than a farming operation.

> "If you were able to use the water in M&I that's appropriated for ag right now, all of the farming even in the lower Valley would go out because all of a sudden that right would get converted to Ute water using it. You know Ute water has bought an immense amount of ag water... They bought land for prices that were totally out of the question for anybody to buy that property and farm on it" (15_Garf).

Respondents explained that municipal water acquisitions keep farm and ranch land cost inflated in part because Ute Water purchases the property with the anticipation of 50 years from now converting that water to municipal uses.

Members of AWSOs in the Grand Valley region of Garfield County irrigate with water protected for agriculture under thirty-year Bureau of Reclamation contracts. The Bureau is a federal agency best known for the dams, power plants, and canals constructed across western states. The Bureau provided funding and engineering for water projects leading to homesteading and the economic development of the West (Rowley 2016). AWSO contracts with the Bureau require that ag water remain tied to the land. Water cannot be sold to other uses including municipal or industrial (M&I). One respondent expressed concern that, "…if water converted to M&I, ag would go out of business because the local municipal water provider would buy it up" (13_Garf).

OG companies participate in a trend across western states of transfers from irrigation to M&I purposes. In Garfield, historic transfers to energy companies moved water out of agriculture beginning in 1949 and respondents are more concerned with municipal water and land acquisitions. Although CAWA does not mention OG use as a potential transfer out of ag,

interview data shows that Weld producers have experienced and remain concerned with water market competition favoring OG's economic and political strength pricing them out of CBT water. When OG water users outbid producers water access is appropriated by another user group with greater economic and political decision-making, resulting in differential access.

Across both counties, OG industry purchases land and water out of agriculture production but may lease excess water back to ranchers and farmers. As urban areas continue to grow, M&I acquisitions in both Weld and Garfield are perceived as driving up water's economic value. But what are the consequences of producers leasing land and water from M&I, including OG companies? Producers have the option of working the land but lose the security and decision-making power of resource ownership.

Leasing land and water from municipal and industrial users

While this research seeks to understand more about water access specifically, respondents in both Weld and Garfield Counties explained that in attempt to purchase secure water access, OG companies also buy ranches and farms associated with those water rights. Companies then lease both land and water back to producers until they need water is needed for M&I uses. Respondents describe both positive and challenging relationships with leasing land and water. We find that when ag water users lose ownership of water, they lose decision-making power on farm and in AWSOs. In addition, uncertainties in farming operations increase.

One Garfield County rancher shared his experiences of leasing his family's water rights back from an energy company. He explained that in this region, the OG companies own land and water as well as the politics and decision-making to influence county politics. OG political influence in the region was echoed in another interview …(include: content from Rink on

commissioners). While "Sam" did not allow me to record our conversation, he explained in detail that once OG companies bought the land and water in the valley where he was raised, his access to grazing was compromised. Companies built private roads and pipelines on trails cutting off access to the plateau where he and his great uncle used to graze cattle. They built structures in the middle of a field, making growing and grazing on the leased property challenging. Sam mentioned the decrease in access to land and water repeatedly and how little decision-making ranchers and farmers have over land and water, as well as farming and ranching operations. Sam believes companies do not care about leases except when maintaining a lease agreement allows companies to keep land under 'ag' for taxes versus industrial taxes where they would incur a higher tax burden. For every one thousand acres owned, they will maintain 20 acres in ag production. Sam was the only OG lessee that agreed to an interview so it is unclear if others had a similar experience.

Other Garfield County producers explicated their relationship leasing land and water from the municipal provider, Ute Water. One rancher, "Dan" shared that Ute's,

> "…biggest concern from a public relation standpoint is that the farm is well taken care of and maintained properly and irrigated properly so as long as we are doing our job, they want to support us doing that job so they've been very good landlords for us…"(2_Garf).

Another farmer considered Ute flexible and easy to work with. He went on to say,

> "the only time I got in trouble was 2012 when we had pretty serious drought and I was kind of counting on some of that water I had leased from them and they found out that they wouldn't be able to lease it…I didn't get that water that I was kind of expecting to get. That just added to the problems of not having enough water all the way around." Across both Garfield and Weld Counties and in both municipal and industrial lease

agreements, when ag water users lose ownership of water (despite the interpersonal relationship with the water owners), they lose decision-making power and uncertainty increases:

> "... when the boom comes back then they [OG] will stop leasing their water….which will have some impact on ag… when a dry year comes they just pull back on all of those

> leases and don't lease water to ag...they would return that water to energy production."(2_Weld).

The municipal or industrial water right owner will lease water to producers during times of surplus but as a right holder, guarantees for ag water user water access is dependent on a wet year, or surplus water supplies.

In conjunction with owning water, M&I usually have to become members in an AWSO to access the water transport infrastructure. Producers are concerned that with OG purchasing more shares in irrigation, reservoir and ditch companies they will have more power in decision-making within the AWSO and eventually transfer more water out of ag,

> "...as a shareholder you start to worry when it gets to that, you know, 30 or 40% of the ditch because ditch analysis that happens...You only find out when that water is gone (3_Weld).

Most commonly, stakeholder-led AWSOs actually hold the decreed water right and each shareholder in the ditch system owns a proportional amount of that right based on their share holdings (Magnuson and Smith 2008). For example, one share out of one hundred shares issued represents one percent ownership of the company and one percent of that water right.

A Garfield County rancher expressed his frustration with getting energy companies to cooperate and pay their annual assessment fee for administration of the water. He shared,

> "the bigger fish starts buying out the little and medium-size fish. I'll use OXY [OG company] as an example because I've had pains with them. They come in, they have 10 shares in our reservoir company. Their assessment eight or nine hundred bucks a year will go unpaid for years. You talk to people in Houston but they don't understand Colorado water law (Garf_20).

Ag water user respondents in both Counties express concerns with leasing water and land from M&I users. When producers lease water and land, they lose decision-making power and uncertainty increases. The integration of M&I into AWSOs and the decreasing producer

presence, including farmers and ranchers leasing from M&I, challenges the social organization at the heart of irrigation and farming in Colorado.

Maintaining agricultural water rights

Energy developers do not always transfer water and land out of agricultural ownership. Instead, they enter into leasing agreements to meet short-term demand, preserving long term water supplies for agriculture. Agriculturalists and their AWSOs use income from leasing water and infrastructure to OG to make irrigation infrastructure improvements, diversifying their income sources. Water is also maintained in the hands of agriculturalists when producers decide the short term benefits of increased income from leasing to OG is not worth the potential risks associated with decreasing insurance protection and market access. This category focuses specifically on Weld County since Garfield County operators already own water rights needed for OG production.

Weld County producers are gaining a new revenue stream by leasing water and land to OG companies:

> "...for the most part it has been a boom for some of these irrigation companies …Farmers Reservoir and Irrigation Company, Henry Lynn, Riverside…the money that they have been able to make by selling to oil and gas has helped them to improve their systems, their infrastructure, buy new equipment, reduce the shareholder annual fees in some cases to nothing."(4_Weld)

Another irrigation company explained that by leasing water to OG, they were able to pay off 30-year loans early with a low risk new revenue stream (Smith_Weld).

The farmers and ranchers are not under the illusion that an OG "boom" will last more than a couple of years. They continue to lease water, land and mineral rights while they can. But not all sell water to OG operators. Producers weigh potential long-term consequences. In addition to water rights having designated beneficial uses, a Weld County farmer may choose to

lease water for a season to OG rather than planting. This impacts crop insurance and disrupts supply contracts. Crop insurance is calculated based on 10 year average. One year of not producing and selling water to OG companies decreases the amount of federal crop insurance:

> "…the big problem I see with leasing is that we use multiperil crop insurance for hale and any kind of natural storms… if I grew corn for 10 years I'd take the yield every year and average that out and that's what they would insure for…so if I lease water to somebody for a year, I get a zero for that so that lowers my insurance going forward for 10 years… you get pretty good money one year you're giving up nine years of history" (1_Weld).

Another farmer in Weld County chooses not to lease water to OG companies since he would loose his long-term and competitive vegetable supply contracts with Denver markets,

> "…if they let those contracts lapse, there is lots of competition to get those back …they weren't interested because long-term contract to supply Safeway or King Soopers with sweetcorn or potatoes for the next 10 years was much more lucrative than a one year deal to not grow something and provide water to an oil company..."(2_Weld)

Farmers leasing water make calculated decisions that any potential long-term negative impacts are worth the two to three years of increased income. AWSOs have been able to pay off loans early, make improvements to irrigation infrastructure and acquire a new revenue stream by participating in short-term water leasing agreement.

Balancing equity in water access

One of the principles of prior appropriation states that water must be put to a beneficial use such as municipal, industrial, and irrigation. Beneficial use refers to the use, or purpose for making an appropriation of water, often defined for economic benefit (Jones and Chech 2009). As more water moves out of agriculture those water rights will be sold to the highest bidder, or the *most* economically beneficial use. As any Colorado water right holder will tell you, 'water flows uphill to money,' a statement repeatedly echoed by interview respondents.

However, our interview data shows that under the surface, AWSOs are working to balance equity in access for farming, a water use at the low end of economic beneficial uses. Two different types of AWSOs, one in Garfield, the other in Weld, are examples of public entities that ensure water is used for not just the most economically beneficial use, but also for a purpose that is both economic and value based. Let's call the AWSO in Garfield, CAT and the one in Weld, FUSE. We use pseudonyms to protect respondent anonymity.

A manager at CAT explains sustainable water use as not helping one water user at the cost of harming another. He states,

> "I think fundamentally it has to be about not establishing one use at the expense of other uses…The value is really…how can you do something that has broad multiple benefits? That's an overarching value for us."

Similarly, the manager at FUSE states:

> "Our reservoirs fill and empty every year for agriculture. So you just got to work with that, it's kind of tough. You'd really love to, ah man, I'd like to make millions but you got to play it as you go so." (Weld_)

CAT and FUSE are both economically viable conservancy and irrigation districts that, based on these quotes, also maintain core principles of equity in water access. Equity in water access refers to the ability for diverse users to procure water for services that meet public needs, such as eating, without being disadvantaged due to the cost of water. In other words, the antonym to differential access. In our market-based system that prioritizes economic beneficial uses, farming may not be as lucrative as OG, but provides undeniably necessary food. Through collective valuing of collaboration and agriculture, AWSOs diffuse risk throughout the local economy.

CAT indirectly maintains water in agriculture protected from transfer to another use type. OG water users are not on the fore of producer minds because OG companies often own water

and if they are not considering buying water supplies, will not be of concern. By OG owning water rights, they are less likely to seek out water from agriculture. Water management and administration organizations would like to see OG maintain their water rights since damage to ag has already been done. This is in contrast to Weld, where OG is outcompeting farmers for water on the CBT market:

> "from our perspective we can develop a water supply and that would help energy meet its needs so then it's not out competing for other sources of supply, then that would be great. And that's what I understand is happening in the Front Range on the short-term market, because there's no supplies out there for energy so they go out into the market and acquire water that would have been used for agricultural purposes…" (2_Garf).

This section sheds light on the important and changing role AWSOs play in balancing equity in and maintaining access to water for agricultural users. The system of prior appropriation is designed for water to be allocated to the highest beneficial use and therefore legally transferring water out of agriculture and into energy production makes sense. Managers and administrators follow Colorado water law while also strategizing, making decisions, and working to maintain agriculture in the regions. Representation of farmers and ranchers by irrigation districts, conservancies, and other AWSOs maintains not just water for ag but also represents a stronghold of farmers working to maintain the highest valued senior or CBT water rights/shares.

Conclusion

We have asked if agricultural water users are experiencing changes in water access related to increased water use for OG development and examine the implications of these changes. Interviews qualitatively capture the changing nature of AWSOs in relation to increased water use for OG development. This paper has offered a descriptive account of Colorado

producers in Weld and Garfield Counties experiencing another new challenge to their water rights and how OG water use shapes their access to water in the short and long-term. There are several other drivers of water use change not thoroughly examined here, including, water bought by municipalities, farmer retirement, lack of successor to farm operations and ownership, crop failure, weather and climate change, and market forces. In the context of decreasing and differential access, we find that AWSOs in both Garfield and Weld Counties balance equity in and maintain access to water for agricultural users.

In terms of OG shaping water access for AWSO's and their agricultural water users, short-term water leasing agreements with OG companies generating income to make irrigation infrastructure improvements, pay off loans, and pay annual membership administrative fees, or 'assessments' helps to maintain water in the hands of agricultural users. In these ways, energy developers meet short term demand, while preserving long term water supplies for agriculture. Paradoxically, OG users are out-competing ag users for access to water in the CBT market in Weld and in Garfield producers associate the increasing costs of land and water, in part, to OG's ability to pay more for resources. When ag water users lose ownership of water they lose decision-making power and uncertainty increases. Respondents have experienced this with increasing OG stakeholders in AWSOs and the need to lease water and productive agricultural land from OG companies. OG purchasing AWSO shares and the short-term leasing agreements collectively indicate industry's integration into rural water organizations and decision-making. Water access for ag users ultimately decreases while the benefits of energy production and extractive water uses migrate out of rural communities.

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CHAPTER 4

AN EMBODIED AND INCLUSIVE SOCIO-ENVIRONMENTAL PEDAGOGY

Oil and gas extraction policies and practices shape agricultural water access and administrative flexibility in Colorado's rural communities. Such policies contribute to increasing social distance between rural-urban populations when rural communities feel silenced or forgotten in the political process (DelReal and Clement 2017). This divide is part of a growing trend of increasing tensions between rural and urban, conservative and liberal, immigrants and nationalists, U.S. residents with differing ethnicities, values, and socio-economic statuses (Blair 2017; Hanson 2017; DelReal and Clement 2017). In response, interdisciplinary learning paradigms have the potential to generate empathy so that policies can be infused with rural understandings, bridging the growing socio-cultural divide fostering long-lasting environmental commitments. This paper unpacks, analyzes and redefines reductionist education theories and proposes that we move toward more effectively shaping long-lasting commitments to the environment and others through an embodied and inclusive pedagogy.

Socio-ecological systems (SES) interdisciplinary pedagogies aim to bridge the social and natural worlds to "achieve a deeper understanding of the relationship between learning, society, and sustainability" (Krasny et al. 2010:464) through a synergy of resilience and environmental education that enhances problem-solving capabilities and enables governance strategies (Plummer 2010). However, SES pedagogies sidestep the importance of physical interactions with nature as crucial to increase learners' emotional connection and long-term behavior change in relation to the environment, other people, their identification as a scientist, and improved

standardized test scores (Frisk and Larson 2011; Jones et al 2012; Buxton 2007; Bloom 1997; Daniels 2012).

What does a pedagogy look like that infuses learners with a greater sense of relationality with their selves, others, and the environment? Such a pedagogy may take place outside the classroom to facilitate multi-sense, or embodied, experiences that develop lasting emotive connections to the physical environment (Carolan 2007; Gruenewald 2008; Bang and Medin 2010). It prioritizes epistemological inclusivity and embodied environmental interactions through the inciting of empathy. By embodied, I mean that we learn through our bodies, that knowledge is relational, and interaction with nature through all senses (touch, smell, taste, listening to sounds, and sight) is crucial to learning (Carolan 2007; Lakoff and Johnson 1999; Payne 1997). Sense-based experiences of our physical surroundings creates multiple types of knowledge distinct from that learned through a single sense such as sight. For example, you gain different meanings about an apple when you taste it versus when you look at it. If the goal is to change ecologically harmful behaviors, learning bodies that contact and interact with biophysical experiences foster empathy for ecological processes (Gruenewald 2008). Environmental education research empirically demonstrates that strategic fostering of human empathy for the natural environment leads to sustained interest in ecological knowledge, pro-environmental values, and actions to protect nature (Sobel 1996; Hart 1997; Kals et al. 1999; Louv 2008; Berenguer 2007; White and Stoecklin 2008). In contrast, traditional content-based classroom learning where a student records, memorizes, and repeats is ineffective in changing behaviors, they must also feel and do (Freire 1970; Frisk and Larson 2011; Jones et al 2012; Buxton 2007). It is through our body's doings that we learn about the environment and foster empathy with others.

Just as sense-based experiences of our physical surroundings creates multiple types of knowledges, the process of inclusivity draws from learners' diverse epistemological resources developed through culturally distinct everyday lives (Bang and Medin 2010). Instead of learning to master and utilize a singular western Cartesian and Eurocentric science that favors a singular, objective, and measurable truth while sacrificing cultural ways of knowing nature and relationships, learners *navigate multiple* and diverse epistemologies. They engage in social interactions with people of diverse backgrounds to exchange sense-based knowledges and actively practice empathy through this interpersonal exchange. This method of "doing" science creates inclusive learning spaces where learners can enter through and share multiple epistemological frameworks and in this way, decrease social distance and political divides (Daniels 2012; Bloom 1997; Stephens et al. 2014).

Knowledge is gained through the understanding of diverse lived experiences, or the recursive practice, habitual doing, and interacting in a highly personal and subjective way. To understand 'lived experience', ask what are a learner's daily activities, habits, and ways of interacting with the environment through their senses and then ask what these patterns tell us about a learner's relationship with the environment and others (Payne 1997). The lived experience is comprised of information gathered by the individual's bodily interactions with the material and social worlds. Reflecting on one's lived experiences connects a learner's memories of experiences with new knowledge claims, fostering long-lasting conceptual advancement in learners (diSessa 1993; 2005; 2006; Inagaki and Hatano 2002; Linn 2006; Clark 2006; Vosniadou 2013) and a move towards empathy. Understanding another's lived experience parallels the idea of empathy as 'trying to sense, perceive, share, or conceptualize how another person is experiencing the world' (Bohart and Greenberg 1997:419). Empathy contributes to

activation of moral principles and increase their valuing of that person's welfare (Batson et al. 1995; Hoffman 2000; Eisenberg 1991). Learners foster empathy and connection to the environment when they have direct, sensory experiences over time. Attending to environmental problems without ensuring that learners have had a chance to develop an emotional connection to the natural world and the diverse experience of other learners, environmental education has at times backfired, when learners get overwhelmed and dissociate from the pain of caring (Sobel 1996).

This paper argues for a shift away from strictly reductionist and rational choice theories while recognizing the utility of holding multiple perspectives. Scientists schooled in reductionism, or the belief that the whole can be reduced to its individual components, certainly need to work together with holistic, embodied sciences if we are to address our multifaceted socio-environmental challenges. Western Cartesian perspectives on science have been the dominant, socially validated way of knowing since the European Enlightenment (Bowler and Morus 2005; Lindberg 2007). In contrast, this paper proposes that we make meanings with and through bodies, emphasizing lived experiences. For example, Carolan examines how a farmer's daily doings of driving a tractor in his field increases knowledges gathered through the farmer's activities and interaction with the physical environment. After many years of working the land, he can tell a lot about the soil type and contours of the field by the way the tractor handles; he creates a unique understanding of the landscape that cannot be understood by a spatially distant non-farmer passing by in a car (2008). Embodied curriculum practices challenge traditional environmental education and SES pedagogies to respond to learners' lived, bodily experiences to create lasting environmental commitments that are understood habitually, by our doings, in the body (Payne 1997; Harrison 2000; Bennett et al. 2013).

This paper explicitly focuses on the theoretical and not the practical components of pedagogy, beginning with a brief introduction to SES pedagogies main theses and processes. To distinguish between SES's assumptions and the socio-environmental pedagogy proposed in this paper, I move beyond the language of SES to outline the tenants of an embodied knowledge and inclusive pedagogy by addressing theoretical issues: (1) the mind/body dualism – a separation that neglects the shaping of knowledge through our bodily doings; (2) how the body channels sense-based knowledge from our surroundings , showing how knowledge is relational; (3) examples from research on farming, agriculture and eaters shows what we mean by embodied knowledge; (4) how different senses channel distinct types of knowledges and how this is important to understanding nature and each other through embodied knowledge processes. I then offer 'culturally relevant education' as an example that values learner lived experiences of cultural knowledge, frames of reference, and performance styles to make learning for ethnically diverse students more relevant to and effective for them (Gay 2010). Finally, I tie together embodiment, inclusion, and empathy through a heuristic activity exemplifying the bridge needed in SES pedagogies to more accurately capture social complexity and shape lasting environmental commitments.

To nurture a way of thinking about learning that values learner's lived experiences and knowledge as embodied and inclusive, I bridge literature on corporality and embodiment (Ingold 2011; Harrison 2000: Carolan 2007; Mol and Law 2004; Thrift 2000;2004;2008; Stoller 2004), educational research on conceptual advancement (diSessa 1993; 2005; 2006; Inagaki and Hatano 2002; Linn 2006; Clark 2006; Vosniadou 2013), empathy research (Bateson et al. 1995; Hoffman 2000; Eisenberg 1991; 1995) and culturally responsive education research (Bang and Medin 2010; Aronson and Laughter 2016).

Socio-Ecological Systems pedagogies: concepts and theories for interdisciplinary environmental education strategies

SES pedagogy builds on SES frameworks to incite a connection between learners, society, and sustainability through model processes including "social learning, multiple-loop learning, reflexivity, allowing for self-organization and other forms of participation, attention to multiple forms of knowledge and governance, and the incorporation of feedbacks or information from the social and ecological components of a system" (Krasny et al. 2010). SES pedagogics ask what kind of environmental learning can enhance resilience at individual and institutional levels, and how would this enhance social–ecological system resilience (Kransy 2010)? Descriptive SES case studies further a "variable-oriented" science that breaks down a case into independent dimensions and examines the individual contributions of each of these to some outcome (Ban and Cox 2017). This paper questions this reductionist way of doing science through ecological structural function and rational choice theories, absence of sense-based knowledge in navigating SESs that shape how we understand the physical environments around us. In addition, 'othering' diverse ways of knowing while universalizing meaning making as western, Cartesian, and reductionist inhibits inclusive, diverse and embodied knowledges.

SES pedagogies rely on a combination of second generation rational choice (Ostrom) and ecological structure-functionalist theories (Gunderson 2003; Holling 1973; Folke et al. 2010). Resilient ecological structure and function is carried over from SES frameworks and resilience theories steeped in ecological processes (Adger 2000; Scheffer et al. 2002; Walker and Salt 2006; Holling and Gunderson 2002) that identify social factors, such as knowledge production and equity, as considerations to insure the functionality of institutional structures. Understanding knowledge and equity as functional components of institutional structures assumes that

institutional designs are solely responsible for behavioral outcomes. Aligned with this perception, Adger et al. suggest that policies promoting inequity "undermine[s] the potential for welfare gains in the future and ... have less chance of full implementation" (2005: 83). However, numerous studies on impacts of participatory and decentralized natural management initiatives show that "far from giving greater rights and decision-making power to disadvantaged groups, these initiatives often create opportunities for further exclusion at different scales…" the effects of which may motivate local elite capture or expanded territorial control by the state (Nelson and Agrawal 2008; Peet and Watts 2004; Peluso 1996 in Cote and Nightengale 2012).

SES pedagogies have nevertheless assumed problematic structure-functional theories prevalent in SES research frameworks: "the ways in which social–ecological systems, such as agricultural communities, watersheds, or cities, sustain function in the face of change, and use change to precipitate reflection, learning, and moving to a more desirable state" (Kransy, Lundholm, Plummer 2010:466). While resilient structure and function may be appropriate for ecological systems, applied to social systems (Abel et al. 2006; Adger 2000; Davidson 2010), the functionality of institutions and normalization as outcomes of institutional designs or structures (Cote and Nightingale 2012; Cleaver and de Konig 2015) has been highly critiqued and cannot adequately capture the complexities in the social world (Pahl-Wostl et al 2011; 2012 Nadasdy 2003; Clever 2000; Evans 2012).

Sriskandarajah et al. speaks to 'othering' by pinpointing the importance of not just recognizing local and indigenous knowledges but valuing epistemological complexity (2010). Knowledge is 'othered' when it's not normalized or recognized as the accepted, standard way of knowing. In these cases, groups of people become classified as "not one of us" and sometimes less worthy of respect and dignity than those that are part of the 'normalized' group. For

example, socialized gender constructions in western societies shape our ideas about what it means to be a "man" or "woman," othering those that do not fit into the binary categories. Normalized categories of different groups within society, whether related to gender, race, class, or cultural, is controlled by groups that have greater political power. Different types of non-western knowledge included as variables in Ostrom's design principles demonstrate the power imbalance hidden 'below the surface' of SES pedagogy. To be inclusive of multiple epistemologies, reductionist and western scientific knowledge would also be included as a variable to be boxed and checked.

Socio-environmental pedagogy: Moving toward a socially inclusive, environmentally embodied knowledge generation

To redefine assumptions about knowledge beyond reductionism, this pedagogy opens the door to learners becoming producers of knowledge that is grounded in their own lived, bodily experiences. The disembodied Cartesian perspective has the effect of 'othering' the environment and different ways of meaning making. Maintaining an understanding that there is a singular objective, knowable reality that is outside the body and can be attained as similar for everyone, creates a harmful distancing that underlies exploitative practices, lack of empathy for the natural environment and empathy for learners with diverse, non-western lived experiences/knowledges. David Sobel, for example, describes how children who have been taught about environmental problems without having had adequate time bonding (through direct, sensory experiences) with nature tend to get overwhelmed and dissociate from the pain of caring (1996). By addressing environmental problems through the cognitive pathway without ensuring that children have had a chance to develop an emotional connection to the natural world, environmental education has at

times backfired, leading to a lack of caring. Just as we cannot exist separate from our environment, the mind cannot exist separate from our bodies. Instead, senses gather the empirical evidence that shapes our subjectivities to navigate through daily lived experiences including how we learn and know about nature (Harrison 2000; Ingold 2000; Thrift 2000; Hetherington 2003; Carolan 2007; 2008; Watt and Lane 2007).

This section examines: (1) the mind/body dualism – a separation that neglects the shaping of knowledge through our bodily doings; (2) relational knowledge defined as both environmental knowledge our body channels from our surroundings and understandings gained from interactions with other learners; (3) examples from research on farming, agriculture and eaters shows what we mean by embodied knowledge; (4) how different senses channel distinct types of knowledges and how this is important to understanding nature and each other through embodied knowledge processes. Based on an embodied understanding of knowledge and diverging from SES pedagogies, learners need to feel and experience the environment to holistically study socio-ecological systems.

An embodied pedagogy values how the 'body' in action and interaction can be a qualitative site of and for inquiry, "…we cannot divorce mind from body when talking about knowledge/s, understanding/s and perception/s of the world … mind is body; consciousness is corporeal; thinking is sensuous" (Carolan 2008: 408-409). We make sense of the world around us through embodied and lived processes:

> "For Maurice Merleau-Ponty (1962), consciousness devolves from embodiment: Consciousness is…being-towards-and-through-the intermediary of the body" (p. 137)... (quoted in Stoller 2004).

Much of the theoretical mental wrestling of redefining subject/object, mind/body dualisms have been tackled (Merleau-Ponty 1969; Thrift 2000; 2004; Carolan 2007; 2008; Lakoff and Johnson

1999; Dillion 2006). At the helm of this redefinition, Merleau-Ponty places the mind, body, and world in a state of perpetual coproduction (1992). Thrift summarizes by suggesting that our mind is in fact embodied and therefore, reality is brought into being through enactment, and truth is mediated through embodiment (2008). In other words, learning does not exist outside of its doing in varied and different practices.

This type of sensual knowledge recursively interacts with and produces our world, experiencing through the senses evolves into habits of doing and understanding (Harrison 2000), and in this way knowledge is relational to our surroundings. Objects will take different forms in different places and practices, or through different lived experiences. When we understand knowledge as relational, multiple and different enactments of the environment become visible and the certainty of a singular a priori reality is challenged (Mol 2002; Macnaghten & Urry).

To understand the environment we interact with it using all our senses. We gather unique types of information from touch, listen, taste, smell, and seeing. In this way, we actively intermingle to come to know the objects around our bodies. For example, Carolan (2007) analyzes the experiences of Community Supported Agriculture (CSAs) as spaces of embodied knowledge:

> "Non-growers …in picking their own food… got a type of embodied education. As one individual quipped, ''You really can't appreciate what goes into growing your food unless you actually participate in that process'' (Nick, 14 July 2003).
>
> Another explained, ''The global food system leaves the consumer out in the cold, largely ignorant of all that goes into making our food – how it is raise, processed, packaged, shipped. [...]We have no idea about what goes into producing the food we eat… barriers are torn down because we can experience the whole thing on a first hand basis'' (Gene, 14 July 2003). Growers like-wise expressed similar sentiments… ''This allows me to know, see, and if I want even touch those I am feeding…'' (Becky, 16 July 2003). The CSAs in question created spaces where people, whether they were producers or consumers, could get to know ''first hand'' the entire food commodity chain from seed to dinner plate."

We learn, change perceptions and even our habits by using senses in new patterns, that is, our "doings" in the world (Harrison 2000). "So thinking 'lies in the body, understood not as a fixed residence for "mind" but as a dynamic trajectory by which we learn to register and become sensitive to what the world is made of" (Thrift 2000; 2004 p. 90; Bourdieu 1995 p. 91; Lakoff and Johnson 1999 p. 13; in Carolan 2007).

SES pedagogies aim to understand the interconnections of social and ecological systems, in contrast, socio-environmental pedagogy argues that a connection with nature must be felt, experienced through our multiple senses and qualitatively understood. In other words, through our sense-based experiences of our physical surroundings that create a distinct type of understanding. Further, this understanding calls on holistic integration of our full selves – all of our senses, and our emotional and spiritual selves. Touch and smell afford direct interactions with the world in a way not easily achieved through sight. In explaining how the act of smelling differs from that of seeing Press and Minta (2000, p. 174) write:

> ''In the act of seeing, one remains oneself; in the act of smelling, one dissolves. The eye looks at something out there and the mind's attention is out there. The perception of the nose seems invasive to the mind because there is an immediacy of the self with the subjective emotion elicited by the other'' (quoted in Carolan 2007).

Distinct types of knowledge are brought in through each unique sense and in this way, we gain an embodied understanding of our physical surroundings. An embodied pedagogy assumes that we learn through our bodies, that knowledge is relational, and interaction with nature through all senses and other people as crucial to learning. When learning bodies interact with biophysical environments, empathy for ecological processes develops (Gruenewald 2008) leading to sustained interest in ecological knowledge, pro-environmental values, and actions to protect nature (Sobel 1996; Hart 1997; Kals et al. 1999; Louv 2008; Berenguer 2007; White and

Stoecklin 2008). Sense-based embodied knowledges derived from habits and conventions of daily life constitute learners 'lived' experience that becomes inscribed into our bodies.

Connecting rural-urban lived experiences: valuing multiple epistemologies to generate empathy and inclusion

Since we learn and create knowledge with our bodies, what we do shapes what we ‘‘see’’ and thus what we know (Mol 2002). As such, an inclusive pedagogy acknowledges lived experiences, or understanding of learners’ recursive interactions with social structures and historical experiences. Daily life consists of habits, conventions, daily activities that are contested, may be unplanned, and are only partially influenced by institutional structures (Cleaver and De Koning 2015). To understand ‘lived experience’, ask what are a learner’s daily activities, habits, and ways of interacting with the environment through their senses and then ask what these patterns tell us about a learner’s relationship with the environment and others (Payne 1997). Lived experiences generate epistemological resources, or memories, experiences, and feelings that a learner accesses to build new ideas/concepts in the context of old ones. Epistemological resources are “…epistemologies developed in students’ everyday lives and employed in various contexts…they vary across contexts and domains, depending upon the appropriateness of fit” (Hammer and Elby 2003 quoted in Bang and Medin 2010:1016). Valuation of epistemological resources gathered through daily experiences helps learners foster deep understandings, in contrast to the less problematic acquisition of facts (Disessa 2005; Bang and Medin 2010).

Daily habits and experiences, or doings with our bodies, shape learners' meaning-making. In his research findings on understanding of the countryside as an embodied, lived experience, Carolan (2008) quotes a rural Iowa farmer:

> "…instead of knowing the countryside from a car on the road looking out at a field I know it from my tractor in the field looking out at the road…you get to know first hand the contours of the land as well as soil type – you know, what spots are wet, which are sandy, stuff like that…When you've been doing this as long as I have you can tell a lot about the ground by how the tractor handles. It's almost like the tractor is part of me."

Carolan explains that a farmer's unique embodied knowledge of the landscape exceeds optical ways of knowing. To know with a body, in other words, involves more than the sense of sight. Emphasis on lived experiences, or the farmer's daily doings, creates a unique understanding of the landscape that cannot be understood by a spatially distant non-farmer driving past. Recalling of unique and relevant existing epistemological resources gained through lived experiences, such as a farmer's knowing of soil types and moisture content, leads to what educational researchers refer to as long-lasting conceptual advancement. The view that learners' multiplicity of intuitive ideas is explicitly recognized and new ideas are built in the context of old ones exemplifies conceptual learning, changing the way we think and understand the world (diSessa 1993; 2005; 2006; Inagaki and Hatano 2002; Linn 2006; Clark 2006; Vosniadou 2013). Embodied curriculum practices that respond to a nexus between the learners lived, sense-based bodily experiences and the physical environment create lasting environmental commitments that are understood habitually in the body (Payne 1997; Harrison 2000; Bennett et al. 2013).

Valuation of lived experiences works double duty to support both a learner's natural tendencies to draw from past sense-based, embodied experiences contributing to conceptual advancement while at the same time supporting inclusive pedagogical practices that build on a learner's unique, culturally distinct experiences. For example, culturally relevant education

methods intentionally draw from learners culturally distinct lived experiences and epistemological resources, improving student learning outcomes in the following ways:

Table 4.3: Connecting culturally relevant education to student outcomes

Outcomes of Culturally Relevant Education	**References**
Increases in student motivation	Bui & Fagan 2013; Civil & Khan 2001; Dimick 2012; Ensign 2003; Hill 2012; Tate 1995; Wortham & Contreras 2002)
Increases in student interest in content	Choi 2013; Dimick 2012; Ensign 2003; Feger 2006; Gutstein 2003; Martell 2013; Robbins 2001
Increases in student ability to engage content area discourses	Civil & Khan 2001; Gutstein 2003; Martell 2013
Increases in student perception of themselves as capable students	Robbins 2001; Souryasack & Lee 2007
Increases in confidence when taking standardized tests	Hubert 2013

(Aronson and Laughter 2016)

An inclusive pedagogy follows lead, working with and through learner lived experiences of cultural knowledge and frames of reference to make learning encounters for diverse students more relevant and effective (Gay 2010). Learners' knowledge is also socially embedded (Macnaghten and Urry 2000) so that the inclusion of school, home, and community life becomes pertinent components to conceptual advancement (Bang and Medin 2010; Hammer and Elby 2003; diSessa, Jabbar and Mirza 2017).

When learners navigate multiple ways of knowing through guided empathizing of multiple and culturally significant epistemological resources, understanding is developed across difference. Empathy involves 'trying to sense, perceive, share, or conceptualize how another person is experiencing the world' (Bohart and Greenberg 1997:419; Keskin 2014). To practice

empathy, instructors facilitate active listening, reflection, sharing in the emotion of the other, and identifying similarities in experience (Hakansson and Montgomery 2003).

In sum, we learn and create knowledge with our bodies during our daily activities, habits and interactions with others and the environment shape what we see and thus our lived experiences shape what we know. Tapping into learners lived experiences supports both our natural tendencies to draw from past sense-based, embodied experiences while at the same time supporting inclusive pedagogical practices that build on a learner's unique, culturally distinct understandings. Inclusive pedagogies support learner navigation of multiple epistemologies including information and ways of knowing generated through our senses. Empathy works to create inclusion of diverse knowledges. Empathy for the environment, for diverse lived experiences, inclusion and embodiment come together to demystify "the other" in the following heuristic activity.

Socio-environmental Heuristic Activity: Bridging social cohesion and environmental commitments

A simple activity used in outdoor classrooms illustrates how a socio-environmental pedagogy engages with learner's senses, lived experiences, and practices empathy across social difference. By way of heuristic, imagine being in a forest with a group of learners and we are just beginning to a lesson on forest ecology. We stop in front of a towering ponderosa tree's orange trunk with branches that start 20 feet from the ground. The instructor asks students to share with a partner: What do you notice about the ponderosa, what do you wonder about it? What does it remind you of? (see Table 4.2 below)

Table 4.2: Example activity[11] tying together embodiment, inclusion, and empathy

Step	Learning Objective	Example Response	Pedagogical Outcome
1. What do you notice?	Make descriptive observations using all senses	The trunk is rusty orange, it smells like vanilla, the bark feels porous and light, the needles taste like something citrus	Distinct types of knowledge are brought in through each sense; Embodied knowledge: we understand our physical surroundings through our bodies
2. What do you wonder?	Development of researchable socio-environmental questions; Sparks curiosity, analytical thinking, and the beginnings of a scientific research project;	Why does the bark smell like vanilla? Why are the branches so high up the trunk when the Douglas Fir next to it has branches much lower to the ground? I wonder how many trees they have to cut down to build my house.	Begins connection between environment and learner's epistemological resources
3. What does it remind you of?	Taps into student's unique epistemological resources, generating embodied/empathetic connection to the tree species and each other	I remember that smell of vanilla from my mom making cookies. The citrus taste in the needles reminds me of the grapefruit my grandma use to make me eat for breakfast.	Inclusion of diverse lived experiences, epistemological resources; Culturally relevant; Conceptual advancement;
4. How is your relationship to the environment similar and different to your partner's? How can you empathize with their situation?	Interpersonal communication, reflection and individual written reflection; Imagine in their shoes, work through events from partner's perspective; Actively understand difference through anticipation of others' emotions; Share reflection with partner	My partner's mother also made her cookies but a different kind. I learned that they go out to cut their Xmas tree and that she spends holidays with a large extended families. Last year her father hurt his knee on the farm, he couldn't help tree cutting, work his hourly job at the factory and her family is trying to decide what to do. What would it be like if my father lost his job	Listen and reflect, share emotions, identify similarities; Empathy for diverse experiences and ways of knowing and understanding the world; Inclusion through valuation of lived experiences;

[11] Content adapted from: The Lawrence Hall of Science. 2016. "I Notice, I Wonder, It Reminds Me Of..." Berkeley, CA. http://beetlesproject.org/

For this activity, the instructor intentionally pairs together students with diverse lived experiences. Step one begins with multi-sense observation to understand the forest through our bodies, or embodies knowledge. Moving into step two, learners question those descriptions, sparking analytical thinking and curiosity. Step three prompts learners to relate the observed, sense-based knowledge from their physical environment to their epistemological resources/lived experiences, bridging embodied knowledge with inclusion of diverse cultural ways of knowing. Also in step three, learners are building new ideas in the context of old ones, facilitating conceptual advancement.

Step four facilitates learners of diverse backgrounds to listen and reflect, share emotions, identify similarities in experience and better understand 'the other's' experiences. The listener becomes an empathizer who imagines what it's like to 'be in their shoes' while working through understanding particular lived experiences from their partner's perspective. Instructors guide learners on conveying empathetic responses, contributing to activation of moral principles and increase valuing of that person's welfare (Batson et al. 1997; Hoffman 2000; Eisenberg 1991) while at the same time building effective communication strategies that supports healthy integration across communities of difference (Maznevski & DiStefano 1996). However, simply placing a diverse group together in one activity is not enough to break down stereotypes and combat 'othering' of learners from diverse socio-economic backgrounds. Research suggests that the more diverse learners participate in prolonged exposure, equal treatment, common goals, and opportunities for cooperation and collaboration, the more likely they are to overcome their biases (Fiske 2008; Van Laar 2005).

Nevertheless, as a heuristic, this activity assists learners to better understand interconnections between both the natural and social worlds. The engaging of multiple senses

strategically fosters human empathy for the natural environment. Making a cognitive connection between epistemological resources and the natural environment through embodied and inclusive knowledges will more effectively capture social complexity in SES interdisciplinary pedagogies.

Conclusion

This paper proposes an embodied way of knowing that redefines how we learn and do science by challenging the SES's pedagogy based in western Cartesian and reductionist science standard born out of Enlightenment thinking. I've analyzed and critiqued rational choice and structural functionalist theories that 'other' non-western ways of knowing at the foundations of SES pedagogy. Table 4.3 presents a summary of the differing educational goals, knowledge assumptions, and epistemological orientations between SES and socio-environmental pedagogy.

Table 4.3: Summary table distinguishing between socio-ecological systems pedagogy (SES) And socio-environmental (SE) pedagogies

	Educational Goals	**Knowledge Assumptions**	**Epistemological Orientations**
SES	Enhance resilience at the individual, institutional and systems levels; Improve problem-solving capabilities	Reductionist Subject/object disconnection; Othering	Western science perspectives replace cultural ways of knowing
SE	Social cohesion; Long-term Environmental commitments; Emotive Connection to Environment and Others	Learn through bodies and senses; Knowledge is relational; Valuing of lived experiences; Epistemological resources	Navigation of multiple including western science; Recognized as gained through lived experiences

This paper proposes an embodied and inclusive socio-environmental pedagogy. By embodied, I mean that we learn through our bodies, that knowledge is relational, and interaction with nature through all senses is crucial to learning (Ingold 2011; Harrison 2000: Carolan 2007; 2009; Payne 1997). By inclusive, I mean drawing on learners' diverse epistemological resources developed through culturally distinct everyday lives to make meaning of socio-environmental interactions. Understanding another's lived experience generates empathy (Bohart and Greenberg 1997:419) and empathy contributes to activation of moral principles, increasing the valuing of another person's welfare (Batson et al. 1995; Hoffman 2000; Eisenberg 1991). Making pedagogical space for multiple epistemologies addresses both the inclusion of multiple ways of knowing about nature and in doing so begins to shape social cohesion between learners. In the example above, sharing with other students of diverse backgrounds generates empathy for the environment and others. Learners connect their memories of experiences with the understandings of another's lived experience.

I suggest that to attend to the increasing social distance in the U.S (Blair 2017; Hanson 2017; DelReal and Clement 2017), in particular the political divides that surface when rural communities feel silenced and forgotten, interdisciplinary learning paradigms should work to generate empathy so that urban-biased resource policies and practices can be infused with rural understandings, bridging the growing socio-cultural divide.

To foster long-lasting environmental commitments that improve human caused ecosystem degradation processes, traditional content education models may not be the best way to engage students. A disconnected subject/object, that an objective reality exists outside of our subjective interpretations and can be measured, shapes thinking that bodies are disconnected from the environment. Such a disconnection allows us to view the environment as external to our

bodies, a distancing that also underlies exploitative, non-empathetic interaction with the natural environment. If we want to create lasting socio-environmental commitments, we change habits by "doing" in the world, forming new daily routines, and using our senses in new patterns (Harrison 2000; Thrift 2000; Carolan 2009).

Research shows that traditional science education and incentive-based behavior change programs, such as payments for ecosystem services or carbon credit schemes, is short term, as behaviors often return to original states once the incentive is removed (Kamenica 2012). Research also shows that incentives risk making us even more selfish, which is precisely the opposite direction from where we need to be heading when we talk about needing to generate empathy and reducing social distance (Kamenica 2012). In contrast, sensory-based field experiences in science education that help learners navigate multiple epistemologies and physical interactions with nature increase learners' emotional connection and long-term behavior change in relation to the environment, other people, their identification as a scientist, and improved standardized test scores (Frisk and Larson 2011; Jones et al 2012; Buxton 2007). Socio-environmental pedagogies should thus avoid separation of students from sensory-based experiences, which contributes to the emotional, intellectual and cultural distancing in their understanding of and relationship to the environment (Pretty 2002; Morgan et al. 2006). This paper has examined how learners make meaning, assumptions and theories that promote environmentally embodiment and socially inclusivity, and the form of interactions that infuse individuals with a greater sense of relationality with others, the environment, and leads to long-lasting attitudinal and behavioral changes.

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CHAPTER 5

CONCLUSIONS:
CONTRIBUTIONS AND REFLECTIONS

This research has made theoretical and practical contributions to Water Governance and Socio-ecological Systems (SES) research by developing tangible methods that qualitatively assess social complexity of the hydrosocial cycle. Theoretically, an analysis of institutions as relational and informal in addition to formally recognized water policy and law, captures the social outcomes of continuity and change in water institutions. The theoretical underpinnings consider all things as simultaneously social and natural so that changes in use, management, and governance of the water produce distinct forms of hydrologic and social, or hydrosocial constellations (Latour 1993; Bakker 2003; Swyngedouw 2009). Understanding the changing nature of institutions as relational, formal, and informal operationalizes the hydrosocial cycle (HSC) by demonstrating how different uses and physical manipulations of water produce different kinds of social relations, and vice versa (Linton and Budds 2014). More practically, this research identifies from where OG operators purchase water and analyzes implications of changing water use for Colorado's agricultural communities.

Theoretical Contributions

Beginning with a historical institutional analysis (HI) of water use for OG development directs us to the importance of relational and informal institutions to more accurately trace historical change in flexibility allowed under the system of prior appropriation, how it has developed differently in Colorado's top OG producing communities, and what this means for institutional outcomes over time and space. This research has operationalized the HI framework

for natural resource institutions, the beginning of an important step in understanding future trajectories and outcomes. HI traditionally focused on *formal* institutions to explain outcomes of institutional change (Mahoney & Rueschemeyer 2003; Skocpol 1979; Goldstone 2003; Mahoney 2003; Brenner 1985; Anderson 1974; Tilly 1975). This research builds on the HI framework by holding a magnifying glass over a moment of change in Colorado's water administration system. Operationalizing the HI framework finds that consideration of informal and relational institutions also play an important part in explaining institutional outcomes. Outcomes are informally shaped and influenced by power struggles, actors drawing on formal institutional rules, local knowledge, and regional relationships to make and remake institutional frameworks that are time and location specific (de Koning 2014; Cleaver and de Koning 2015). To demonstrate how policies shape outcomes, Colorado's water right institutions must be analyzed in relation to other interacting institutions, in this case oil and gas. This research has pushed the HI framework to processes and interactions that link Colorado's energy and water institutions across policy topics and levels of government instead of viewing them as evolving in isolation.

While often cited water policy and governance research argues for the creation of flexible institutions that have the capacity to adapt to increasing environmental and socioeconomic uncertainties such as climate change (Folke et al. 2005; Pahl-Wostl 2012; Gallaher et al. 2013), the social implications of administrative flexibility have received less attention. SES frameworks do not tell us *what* should be flexible, depoliticizing aspects of institutional change (Evans 2012), an important oversight this research addresses.

Attending to relational and informal institutions as part of the HSC had theoretical implications for understanding the importance of AWSOs as unappreciated but extremely important actors in the future of ag water access and flexibility. When OG developers purchase

water rights, becoming shareholders in previously agricultural-dominated AWSOs, they have more decision-making within these organizations and AWSOs take on the role of water manager and allocator for non-agricultural uses. Water access for ag users ultimately decreases while the benefits of energy production and extractive water uses migrate out of rural communities. The integration of M&I into AWSOs and the decreasing producer presence, including farmers and ranchers leasing from M&I, challenges the social organization at the heart of irrigation and farming in Colorado.

This research has additionally considered how such water policies and practices contribute to increasing social distance between rural-urban populations when rural communities feel silenced or forgotten in the political process (DelReal and Clement 2017). How can we infuse policy with rural understandings and generate a greater sense of relationality with others and the environment. At a time when social divisions are increasing in the U.S. (Blair 2017; Hanson 2017; DelReal and Clement 2017), SES pedagogies do not foster empathy across social difference or for the environment. This is because SES has a basis in reductionist ecological structural function and rational choice theories that rely on a disconnected subject/object dichotomy - where our subjective selves are disconnected from an objective reality. Understanding the physical world as external, separate from ourselves renders alienated disconnections from others and consequently a disconnect between ourselves and the environment (Heshusius 1994; Carolan 2007; Harrison 2000). Natural science methodologies rely on distance, the idea that the knower is separate from the known, an epistemological stance (Heshusius 1994). For this reason, and despite best efforts of grappling with complexity through systems level thinking, SES pedagogies are best suited for descriptive case studies (Taggart-Hodge and Schoon 2016; Tyson 2017).

To address societal need for cohesion across difference and a deeper connection to one's physical environment, this research develops a pedagogy that values learner's lived experiences and knowledge as embodied and inclusive. I bridge diverse literatures on theories of corporality and embodiment (Ingold 2011; Harrison 2000: Carolan 2007; Mol and Law 2004; Thrift 2000;2004;2008; Stoller 2004), educational research on conceptual advancement (diSessa 1993; 2005; 2006; Inagaki and Hatano 2002; Linn 2006; Clark 2006; Vosniadou 2013), empirical empathy research (Bateson et al. 1995; Hoffman 2000; Eisenberg 1991; 1995) and culturally responsive education research (Bang and Medin 2010; Aronson and Laughter 2016).

Practical Implications

This research journey began inside the Colorado Water Institute at Colorado State University on as part of a statewide, National Science Foundation project. As a research assistant on the water quantity committee, I was charged with answering the question: Where are OG operators getting their water, how much are they using, and how much are they paying? When I learned the state's division of water resources department admit they did not have compiled records and in some cases no records at all on how water was moving across the landscape to hydraulic fracturing operations, I knew this research would have practical implications at the local, state, and potentially national levels. This work additionally offers a direction to bridging social divides in a time of increasing social distance between rural-urban populations. The pedagogy presented proposes a theory and method for learners to collaborate, experience and understand people with different life experiences and backgrounds. My hope is that this pedagogy will bring credence to a new interdisciplinary learning paradigm that attends to both social and natural worlds, their interconnections and dependencies.

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APPENDICES

APPENDIX A

INTERVIEW GUIDES

A different interview guide was necessary for the different groups related to water governance in Colorado: producers (including farmers and ranchers) water management entities (including division engineers, conservancy districts, irrigation and ditch companies). I used a modified version of the 'management entities' guide for OG companies and water lawyers. I used the same guides for in Garfield as in Weld County.

Interview Guide for Producers: Farmers and Ranchers

I am a PhD student at Colorado State University and work with the Colorado Water Institute on a project with Reagan Waskom. The purpose of this study is to understand how oil and gas, a relatively newer water use, shapes other water uses. Also, I'm wondering if and how water use for oil and gas influences and is influenced by programs where ag water is leased or sold to other uses. Industry has had an important influence on the development of communities and economies on the west slope but there is very little written about their influence on water use. I'm also interested in how different groups of people perceive flexibility in the system of prior appropriation.

Your answers are completely anonymous. Your name and your answers will not be identified as pertaining specifically to you in anything I write about the interviews. The first few questions are questions I ask everyone to learn more about the … it essentially helps me categorize the respondent based on particular variables

1) Can you describe what kind of farming or ranching you do and how you get the water you need for those activities?

    a) How long have you been farming/ranching in this area? What generation are you?
    b) Will your kids pick up on the operations?
    c) What crops/animals and other products do you produce?
    d) How many acres are you irrigating?
    e) Where (and from whom) does your water come from? What is the priority/seniority of your water right?
    f) Are you a member of the local irrigation/ditch company?

2) I'm trying to get a sense if and how water right administration has changed in your county/water division over time, particularly since you started farming/ranching. Have you noticed any changes in your interactions with the division engineer; the water commissioner; ditch/irrigation company?

    a) From your experience, do you notice any difference in the flexibility of use since you started farming/ranching? What does having flexibility in the water right system mean to you? What would this look like?

b) What about change cases? Are people able to access water without going through the long and costly change cases? How so?

3) Since oil and gas has become a water user, what changes have you seen?

   a) Have you noticed selling, exchanging, or leasing between agriculture/ranching and industry? I'm trying to get a sense if it's common or widespread in your county/community/division.
   b) Has your ranch/farm leased water to industry?
   c) From your perspective, how have these arrangements worked out? Financially?
   d) Have there been changes in the cost of leasing water? The price of water on the market?
   e) Have they impacted your water rights or access to water?

4) What are your thoughts on oil and gas development in Colorado?

   a) What about the pace and scale of development?
   b) Have you leased mineral rights?
   c) Can you tell me about your interactions with industry representatives?

5) Has the ability to sell or lease your water to oil and gas development influenced your participation in *(name of regional collaborative)*?

6) Do you have any other thoughts on oil and gas development impacts on your farm, particularly water supply?

7) Is there anybody else that you suggest I should talk to? For example, people that might agree with your perspective and also people that might have a different perspective?

8) I need to quickly get some basic demographic information if you don't mind.
   Age: _____
   Sex: _____
   Occupation: _____
   Length of residence in community: _____

If I have any further questions or need clarification of anything you said, would it be all right if I contacted you again? Yes____ No____

(Note: these questions may be reordered in any interview, according to the circumstances and the interviewee's interests.)

<u>Interview Guide for water management entities (division engineers, conservancy districts, irrigation and ditch companies)</u>

I am a PhD student at Colorado State University and work with the Colorado Water Institute on a project with Reagan Waskom. The purpose of this study is to understand how oil and gas, a relatively newer water use, shapes other water uses. Also, I'm wondering if and how water use for oil and gas influences and is influenced by programs where ag water is leased or sold to other uses. Industry has had an important influence on the development of communities and economies on the west slope but there is very little written about their influence on water use. I'm also interested in how different groups of people perceive flexibility in the system of prior appropriation.

Your answers are completely anonymous. Your name and your answers will not be identified as pertaining specifically to you in anything I write about the interviews. The first few questions are questions I ask everyone to learn more about the … it essentially helps me categorize the respondent based on particular variables

1) Can you tell me about (*entity name)*? How long have you been in operation in Western/Eastern Colorado? What are the organization's primary roles and goals?

    a) What are some of the most pressing water issues in the area?
    b) What do you consider the most important values to follow for sustainable water use?
    c) What are the major issues or challenges that organizations like yours have in addressing these issues?

2) Can you tell me about how your organization manages water? Does (*entity name)* own water rights?

    a) What entities/who uses the water and for what purpose?
    b) Are you looking to acquire new rights or sell the ones you currently manage?
    c) Are they senior or junior? Single or multi-use?
    d) Do you lease to oil and gas uses?

3) Can you tell me more about the types of water rights (*name of entity)* manages?

    a) What does it mean for (*name of entity)* to manage/lease this type of water rights? What are the restrictions in practice?
    b) Do you have the flexibility that you would like to lease (to multiple uses) or leave your allocation in the river?
    c) Do some types of water rights have more flexibility in use than others? How so? How might more flexibility be implemented under the system of prior appropriation?
    d) In your own experience, what are the concerns with having more flexible water rights?

4) On the basis of your experience, what would you say are the most important changes that have occurred in recent years or are now occurring related to water rights?

    a) Have there been transfers to new uses, changes is pricing, leasing values? Have you noticed any new trends?

b) How has state oversight and regulation changed? What about the agency's relationship with the division office?
c) What are your thoughts on these changes? Who is impacted and in what ways?
d) How is this different from administration in the past?

5) What changes have you seen or are seeing in water use related oil and gas development for (*name of entity)* and users in this area in general?

   a) Have there been efforts in your area to sell, exchange, lease, or share water between agriculture/ranching, or other users and oil and gas developers?
   b) From your perspective, how have those efforts worked out?
   c) Have there been changes in the cost of leasing water? The price of water on the market?
   d) Have they impacted your water rights or access to water?

6) How do you see the future of water use for oil and gas in your area?

7) Given the issues your agency has had with water rights (esp. related to oil and gas development), what needs to happen, in your view, to address the problems we've discussed?

   a) How might these changes happen and who would be involved?
   b) What roles would you agency, local organizations, and the state have?

8) Is there anybody else that you suggest I should talk to? For example, people that might agree with your perspective and also people that might have a different perspective?

9) I need to quickly get some basic demographic information if you don't mind.
   Age: _____
   Sex: _____
   Occupation: _____
   Length of time with entity: _____

If I have any further questions or need clarification of anything you said, would it be all right if I contacted you again? Yes____ No____

(Note: these questions may be reordered in any interview, according to the circumstances and the interviewee's interests.)

APPENDIX B

FOCUSED CODES

These codes were exported from NVIVO version 11 and are the raw data supporting the analysis in Chapter 3: *Watering Colorado's Oil Patch: Agricultural Water Access and Equity.* Each code is composed of references from respondent interviews and is identified by county.

CODE: BALANCING EQUITY IN ACCESS

Internals\\11_Garfield_Transcribed - § 2 references coded [3.47% Coverage]

Reference 1 - 1.97% Coverage

The Yampa is light on administration, the Yampa the white pride themselves on not having administration. A lot of that is really not good for wildlife in the river because people diver more than they need and outfall we forced administration a little bit because there is an instream flow and that is how you would protect water released for a purpose. So they use was in stream flow, we had stored water that had a decree that allowed for that to occur so that was is very expedited process since the decree allowed for instream flow. All we had to do was a phone call in brief letter, coordination with the conservation board to meet they're in stream flow working to dump 20 the 30 CFS and the request to water resources was that you would administer this past headgates. So what's ever there… we want to make sure that gets passed all those headgates because it's stored water in priority, You can't allow anybody to take that.

Reference 2 - 1.50% Coverage

I: do you have a sense if oil and gas water use restricts access by other users, including the environment?

P: it just makes it harder to make everything work. Like on peons Creek we had some water rights, the low end of the creek crossover parcels, There were native Fish concerns no in streamflow on the last chunk of ground below really the calling right. So oil and gas would pull up to a bridge on on our property across P on's Creek below the structure and stick their hoses in and sucked the last drops out of the river basically. And there was nothing we could do about that. We had no leverage out all except saying don't do it on our land. So they wouldn't drove in made a little pad on somebody else's land.

Internals\\12_Garfield_Transcribed - § 1 reference coded [2.48% Coverage]

Reference 1 - 2.48% Coverage

I: you get the sense that through the River District's participation in this whole process with the development and implementation that it's created a shift in perspectives in dealing with one, with a diverse group of stakeholders… I realize there's a lot of details that I'll never build a pull together… And then also the way the district deals with the environment as a stakeholder?

P: well, it's changed the way we've collectively on the Colorado looked at this… look at the

main stem on the Colorado, the Fish program is a benefit to the basin from water quality and recreation perspective.. from a stream flow perspective so now the way we look at this is we know there is competing needs.

Internals\\2_Garfield Transcribed - § 2 references coded [1.75% Coverage]

Reference 1 - 0.92% Coverage

that's the more politically liberal spectrum of our district. Then you come down to Moffit County and Garfield and Mesa and Delta County and Montrose County and politically more conservative, right? But not as enthralled with environmental and recreational uses of water. So it gets to be a balancing act for us.

Reference 2 - 0.83% Coverage

And so what we are trying to work on right now and what the river district and I'm trying to support is well what could we do by way of putting your place flow protections on the Yampa but doing it in a way that doesn't conflict with other uses of water that will need to be made in the future.

Internals\\2_Weld Transcribed - § 1 reference coded [0.82% Coverage]

Reference 1 - 0.82% Coverage

Cities want certainty and they need to know they have the water supply for their citizens or users when they turn on the tap, they need to make sure they have (?) water coming out you know, but at the same time I think that through the Colorado water plan there's going to be an emphasis on trying to keep ag production going around the state

Internals\\4_Garfield Transcribed - § 1 reference coded [0.90% Coverage]

Reference 1 - 0.90% Coverage

I think the only impact would be once again state engineer watching things more closely and making sure things are done properly. They've been pretty strict that if you're going to lease water to a gas company you have to show that you have that water and the right to lease that water instead of just letting them go and pump water out of a pond that may be someone else's water.

Internals\\6_Weld Transcribed - § 1 reference coded [1.39% Coverage]

Reference 1 - 1.39% Coverage

t's not like a constant use like what we need for milk cows or for a feed lot, beef animals or whatever. In the summer time, we need water every year to grow corn and to grow feed for those animals. But the oil and gas when they are developing then they need it and then once it's developed and all their processes have been done by cracking the site and everything and then they are finished. And they don't need it anymore and then move on to the next thing.

Internals\\7_8_Garfield Transcribed - § 1 reference coded [1.27% Coverage]

Reference 1 - 1.27% Coverage

I think the basin roundtables have a number of duties or goals, objectives, and one of them is to develop and understand what the future of water use will be and to identify IPPs projects that

could meet future demands so that's one of their charges. They also work through the 1177 and 217 funding sources to distribute water resource development funds to various entities.

Internals\\7_Weld Transcribed - § 2 references coded [2.82% Coverage]

Reference 1 - 1.65% Coverage

have you noticed any other new uses or changes in pricing? So of, I guess you may not be in direct contact with all of that.

P: Prices have gone up. They really spiked in the earl 2002, 2003, at first, when we had that really bad drought, they spiked up, and then we got wet and they kind of plateau-ed, but now they are heading back up. I can't tell you about the exact numbers but the last time I heard about the share North Poudre I was pretty surprised. Yeah. Wish I could invest in it.

Reference 2 - 1.18% Coverage

So what sort of effects have you seen from water from the sold or exchange between ag and oil and gas?

P: Well just, inflate the price. Oil and gas, they've gotta have the water. They've got millions invested at that site, they've gotta have the water. So they will pay whatever it takes, something, to get this million-dollar project to work

Internals\\Harris_Mark_Garf_9 - § 3 references coded [4.42% Coverage]

Reference 1 - 1.59% Coverage

So you have this tension of protecting the financial interest of the water users you represent and honestly the largest amount of proxies are going to come from the act sector, you have that perspective that's very prevalent and that's the way things are organized stay that way, but you have to keep thinking about the interests of the other parties. Number one we should feel obligated to do so and number two we should be responsible for all of the customers. Again what that requires, and I'm a farmer too, those obligations to commercial agriculture versus the town Folkes, And they are different,

Reference 2 - 1.39% Coverage

You really fared out the customers, what we did was in thinking that we … say that we have a horticulture, landscape delivery water service, commercial agriculture delivery services … there's no way to consider all of the users from a strictly assessment basis. So what we did was something that looks much more like a utility would do… we added a plan investment fee Account the more water you use the more you pay. But the way we see it everyone has the same investment and not roller damn to make sure we continue to bring water down

Reference 3 - 1.44% Coverage

Is that worth something to someone? Well I've spent the last two years trying to figure out who and foe how much. They will be our partners, and one of the things that EDF brings to the mix is it innovative infrastructure projects, impact assessments, buying down the cost of these incredibly expensive projects with use of monies from people who want some return, but want to make part of their return the social benefits that their monies can provide.. and we'd like to try and find ways that we can support that and perhaps deliver those benefits

CODE: ACCESSING WATER FOR OG

Internals\\1 Garfield Transcribed - § 2 references coded [4.24% Coverage]

Reference 1 - 2.98% Coverage

I: So, in terms of the oil and gas aspects, do you…I assume you don't, but do you lease water to oil and gas use and industrial use?

P: No, we really don't have any connection right here with in this grand valley. The oil and gas development really doesn't affect us much. You get up north, well Carlisle does, you talked to him already. He's making big money.

I: Oh, I'm sure he is. He's selling the mineral rights and everything. He was very frank with me I think. I felt like he was….yeah, he was very clear.

P: It's really, the one's who have water rights and I toured when I was on the state conservation board, we toured a bunch of the area up in the the Meeker area and all up in that area and of course a lot of those ranches and that ag water has already been bought up by the energy companies a long time ago, so that will be converted.

Reference 2 - 1.27% Coverage

I: I'm looking at that. I'm talking to people over there as well. I've realized that when I came here, well there aren't really any or as many or many at all in that region anymore since it was all bought up already. I guess, someone was saying it wasn't very highly productive land in any case.

P: Yeah, yeah.

I: So that's starting to make sense I suppose.

Internals\\10_Weld Transcribed - § 3 references coded [3.47% Coverage]

Reference 1 - 1.36% Coverage

definitely leasing water not buying. These guys, The oil patch, a boom and bust industry. Even before this last bust I've spent a lot of time in Wyoming, Casper, Douglas. It's boom and bust and they don't want anything… And when it comes to frocking, It's a short term, you fractal well and then you go on. It's not they're going to Frak that well every year, they're not going to Frak that well every year.

Reference 2 - 1.55% Coverage

The point is that my company signed that contract, the two year contract, because it is a boom and bust and they're saying we got a strike when the iron is hot and that's what we're trying to do. You've got to take advantage of this because it's not going to be here… we have 40,000 acres that's pittance compared to the whole basin out there where they're drilling. If they're drilling underneath our service area, they hired me to be ready to take advantage of it.

Reference 3 - 0.56% Coverage

They're very specialized… it's a phenomenal operation

19:57

so we've been very diligent on if they call for a water. We have never failed. That's where they have me.

Internals\\11_Weld Transcribed - § 1 reference coded [4.31% Coverage]

Reference 1 - 4.31% Coverage

I don't know if I have a specific example, I guess it would be more along the lines of, Like on the west slope sometimes the oil and gas industry they've got different facilities they need to build and they do need some water too so they'll just buy up a place. They don't really need it all but maybe they need a little bit of it for some facility. But to them is just like, It's peanuts to them. So I've seen some of that where it's back to the issue where the land and the water, the surface land and the water costs, both of those are way down on the scale compared to the scale of things that they're working with.

Internals\\3_Weld Transcribed - § 1 reference coded [6.21% Coverage]

Reference 1 - 6.21% Coverage

You mentioned Anadarko and Noble buying shares up, those were bought out of ag I assume?

P: Yes.

I: And…aside from that, have you noticed other selling, exchanging, leasing between ag and other ranching….

P: Under PVIC, that ditch…there are I think 4 shareholders who took shares to court and had them given a dual designation as augmentation or agriculture. What they are doing is diverting in the, I think in March they can designate to the court what they choose to do with that share water whether it's to be used in the production side of things or augmentation. Then what they are doing is they are augmenting and sending the water to augmentation ponds and sending the water to oil and gas from their wells with their share of water use as augmentation for that well. So it gives a little more flexibility to oil and gas companies as far as where they pick the water up, they can hook right up to a well and pump it if they have derived 40 to 50 acre feet of pumping credits from a well , obviously that doesn't all exist in one fell swoop but they can sell that water off as it's needed to oil and gas. When the wells were more prevalent, when there was a lot more activity going on they were seeing some benefit to it. As wells have backed off, as frack activity has slowed down, there's less of that. The biggest place that we have seen competition for water between oil and gas for ag has been in the CBT water.

Internals\\7_8_Garfield Transcribed - § 1 reference coded [3.33% Coverage]

Reference 1 - 3.33% Coverage

o there's a little bit of energy out of our facility up on the Yampa, there have been many filings in the Yampa and especially in the White, the (Peonse?) specifically, you know energy conditional water right filings, there have been many agricultural water rights that have been

changed to industrial use.

I: which county is this?

P: it's throughout, well wherever there is energy it's going on.

I: I'd like to hear more about that.

P: So agricultural water is for sale in many, all over the state of Colorado and other states I'm sure as well. In many cases this commodity that's traded year to year or leased year to year to various municipal or industrial users who have interest, so they're…I know particularly of a number of water rights in the Peonse, in the white river basin.. when you talk about basins, the river basin vs. the structural basin which is the Peonse I might talk about the peonse basin in the same sentence as the white but that's a river basin vs a structural basin.

Internals\\7_Weld Transcribed - § 1 reference coded [2.41% Coverage]

Reference 1 - 2.41% Coverage

I don't know if that's the right term but there are a few guys out there that maybe work for a ditch company and they are handling the deals between the oil and gas companies and the ditch company or even, probably the water districts, have the same kind of guy or an energy company will actually have one. I'm trying to think who he works for, that guy.

I: Yeah, who is he? (Laughs)

P: Yeah, he works for an outfit out of Utah. So, I don't know. I don't know how he landed that.

I: So he basically sets, he does sort of the sales?

P: Yup. He is in water sales.

I: Okay, and he may work for, or maybe employed with multiple people or maybe just the company the energy company.

P: Just the energy company, or whoever.

Internals\\9_Weld Transcribed - § 4 references coded [4.79% Coverage]

Reference 1 - 1.02% Coverage

We don't have much plan on going back and purchasing older rights. We are right now building a another reservoir, a pond and we're going to have a 2015 water right potentially but it's really small but it would be used for oil and gas uses but that's one of the reasons we're having to rent water because some of this water like the CBT water has left our system.

Reference 2 - 0.44% Coverage

Now, if a farmer has his own CBT water, We would probably allow them to use their own CBT water but no one has asked that question. For fracking on his farm.

Reference 3 - 0.91% Coverage

If he wants to, he could sell it to an oil and gas outfit, or lease it on an annual basis. But that's a lot less money then the actual Fracking water itself. You can go rent CBT water for 100 bucks all you want. But when it comes to doing the fracking it several times that is what you get for the water when you're doing that.

Reference 4 - 2.43% Coverage

well, I can mention we are almost done building a small pond down along the river, we are able to get water quicker there and it's on the river, We can put water back in the Platte or we have agreements to transfer water north, get it into other systems and that's where these other pipelines come in. We can tie into those. I have meetings on that next week. Tying into those and providing the water for those instead of trucking, I mean a lot of the stuff it's going on right now is being pumped, pump for several miles. You don't see the trucks on the road like you did three for five years ago. They'll put a pump in a lake and pump it for 5 miles. In a pipe line a little plastic line. It's a lot better on the roads, more efficient for a lot of reasons. It costs less too. We're trying to get involved in a a infrastructure a little bit to the extent that we can.

CODE: DIFFERENTIAL ACCESS

Internals\\10_Weld Transcribed - § 1 reference coded [1.40% Coverage]

Reference 1 - 1.40% Coverage

I used to lease a lot of water for farming in some of my contacts well tell me that the oil patch called them, The oil patch will pay three times as much as a Farmer can… all the way up to 10 times, I've seen 10 times what a Farmer can afford. These entities that are renting have always rented to farmers because that was their market before this boom and now the oil patch people come around and you can't rent from, Right now

Internals\\11_Garfield_Transcribed - § 1 reference coded [1.35% Coverage]

Reference 1 - 1.35% Coverage

I: have you noticed a change or increase in cost of leasing water in general or maybe in relation to oil and gas?

P: I haven't really. Right now I think it's a little depressed just because there's not as much activity. It certainly changes if you have a combination of drought and higher activity. Those years and 2003 2004 and even 06, 07 when water was plentiful and literally they could pull tanks up with big hoses and just Phil tank trucks up with water almost anywhere in there was live water because there wasn't any call. But when you have that combination of drought and higher activity, that price of water go shooting right out

Internals\\11_Weld Transcribed - § 1 reference coded [3.83% Coverage]

Reference 1 - 3.83% Coverage

have you noticed any changes in pricing or leasing values and water..

P: absolutely, we do see that. Colorado water plan tries to address these issues but when it comes to economics there's some industries that are just going to keep losing out and farming being one of them because they barely make money anyway. It's almost just a lifestyle. Well, I should say that because it's important industry for all of us to eat. The economic seminar that the cities and the industry likely than gas cans pretty much outbid anybody for water

Internals\\15_Garfield_Transcribed - § 3 references coded [6.07% Coverage]

Reference 1 - 1.43% Coverage

If you were able to use the water in M&I that's appropriated for ag right now, all of the farming even in the lower Valley would go out because all of a sudden that right would get converted to Ute water using it. You know Ute water has bought an immense amount of XXXX,

Reference 2 - 0.53% Coverage

- if changed ability to use water for multiple uses – take away from farming b/c can sell to energy

Reference 3 - 4.12% Coverage

All of these farms and ranches that were huge huge 50 years ago and then they have six kids and one person stays there and they get maybe half of that ranch given to them but they have to buy the other half and the property values today versus what they were 50 years ago is totally cost prohibitive to ever make a living on a ranch in Plato valley. A lot of that has to do with what has kept our ranch cost inflated is you water buying a property with the anticipation of 50 years from now converting that water to municipal uses. They bought land for prices that were totally out of the question for anybody to buy that property and farm on it.
- UTE water buying property for water –
- OG companies also > > so they have a bidding competition – land price up to buy the water!!!

Internals\\1_Weld Transcribed - § 5 references coded [8.16% Coverage]

Reference 1 - 3.56% Coverage

P: So we're sitting here going hey guys we need to get our act together before the cities come in and just take it all so we got a group of people together…it's a small group, it's john stalt, Reagan, Allan Brayman, two farmers from upstream, two from downstream, myself who is kind of almost in the middle trying to get everybody talking and kind of back on the same page and our thought was get that started and we can widen the group as well. One of the things we brought in a couple people from oil companies, part of our thought was there's some sites around that are reservoir sites that are abandoned so what if the oil companies could come in and redo those sites…ag could give them the water to put in there and they figure a seven year plan is all the oil and gas companies want. So after seven years they would give them back to ag and we would have more storage.

Reference 2 - 0.76% Coverage

I: Is that…do you think if they were to come and you needed the water for the crops you'd just be like heck no?

P: Yeah, probably. Unless it was so high priced that you couldn't turn away.

Reference 3 - 1.80% Coverage

P: It used to be farmers would lease water to each other so if you and I were farming and you ran a little short I have some extra I could get you and maybe what I have isn't enough to cover your needs but with 2 or 3 other guys it could and then maybe a different year you have excess and I'm short and we used trade back and forth like that all the time.

I: but if they're leasing that water to other uses then is that less…

P: yeah that water is gone.

Reference 4 - 0.62% Coverage

P: so we used to see people lease reservoir water a lot and now they don't lease it at all because that's augmentation water to keep their wells full.

Reference 5 - 1.42% Coverage

P: yeah it could be but what happens when the lease is up how does that affect your business as a producer when you pick it back up and carry on again? Because to me this soil is all setup, it's been highly fertilized and intensively managed and if you take water way, it's not going to produce very well for quite a while because it's just too (?).

Internals\\2_Garfield Transcribed - § 1 reference coded [1.24% Coverage]

Reference 1 - 1.24% Coverage

So from our perspective we can develop a water supply and that would help energy meet its needs so then it's not out competing for other sources of supply, then that would be great. And that's what I understand is happening in the Front Range on the short-term market, because there's no supplies out there for energy so they go out into the market and acquire water that would have been used for agricultural purposes, right?

Internals\\2_Weld Transcribed - § 5 references coded [7.90% Coverage]

Reference 1 - 0.62% Coverage

Yeah they have to be used in Northern area but still there's that disparity there.

I: Yeah so that could have potentially affected farmers who may have wanted to lease that water that couldn't compete with that.

P: Right, that couldn't compete with that.

Reference 2 - 1.56% Coverage

I: Could you say that that impacted any other users or water rights besides farmers?

(28 minutes and 5 seconds)

P: Well even in the…it could potentially say impact even municipalities in a very dry year or a series of dry years….most municipalities have sufficient reserve that they are not really going to be impacted but certainly some of the smaller water service providers and municipalities could

end up with some issues if we had, especially a series, of dry years in a row and the boom came back. I mean currently it wouldn't be any problem because demand is, for oil and as at least is way down, there's really little demand right now.

Reference 3 - 0.80% Coverage

I mean there were probably some I'm not aware of you know certain instances when maybe a farmer or producer was trying to lease water and it didn't happen because potentially oil and gas took the water, but I didn't hear about that on a widespread basis but I would guess there were probably a few instances where that happened.

Reference 4 - 3.05% Coverage

I think a lot of the boom came from the exploration but I believe they do need some water to continue production, not nearly as much as when they are doing fracking but…so I expect those companies, they may cut back and kind of scale back their operations but there will probably always be a little bit of demand and some of those companies will probably still be around by the time the next boom comes and then the oil companies gear up and now they may not be fully utilizing all of their available supplies, they may be trying to lease them to other folks for something and when that happens or when the boom comes back then they will stop leasing them and start….which will have some impact on certainly on ag and it will probably be a lot like cities like Greeley where one year they have excess supply so they have a program where they try to lease much of that excess supply to producers, when a dry year comes they just pull back on all of those spot leases and don't lease water to ag. I expect SORAN and some of those other companies, they may not be leasing to ag but they may be leasing to other folks short time and maybe some of them will be leasing to ag but then those short term leases would then go away and they would return that water to energy production.

Reference 5 - 1.87% Coverage

I: but it's just like so what does that mean for future uses…is it that if you have, and this is an oversimplified way of thinking about it, what's keeping the conclusion being drawn that if you have a lot of money then there's flexibility and if you don't have a lot of money there's no flexibility?

P: Well that is a lot of it. You know, a lot of times just from an engineering standpoint I can look at a problem and say I bet we could do this and it would solve this problem, but then when you look at what that would cost, yeah for better or for worse, farmers often just because of the nature of farming may not have a lot of money at least to throw at that problem where somebody like oil and gas or even a municipality, they can spread a big expense over a lot of different people,

Internals\\3_Weld Transcribed - § 4 references coded [17.68% Coverage]

Reference 1 - 3.49% Coverage

The biggest place that we have seen competition for water between oil and gas for ag has been in the CBT water.

I: that keeps coming up. Yeah.

P: There's only one ditch that we can rent CBT or lease CBT water…we don't own any CBT water ourselves…and bring it through that's the platte valley irrigation company, they own part of sandhill lake and bring the water down through Coolridge and dump into sandhill and sandhill into the platte so that's the only delivery vessel that we have here to bring that water to the farms. There's talk of a pumping station out of St. (Brain?) And up to one of the headgates to possibly give us a few more options but that's the biggest place that we've seen the competition because they obviously can bid a whole lot more on an acrefoot of CBT water than we can.

Reference 2 - 7.94% Coverage

I: So how has that played out on the ground in terms of water access for various users?

P: In 2012 if it had been as big an issue then as far as drilling activity I think we would have seen it a little bit more the past few years but we've had substantial water supplies, good snowpacks to run off, good rains, all that good stuff. So you don't see it quite so much as a competition right now other than when they put a bid in for CBT, they put a bid in and it's going to get them water where as we are trying to figure out how low we can go and still obtain CBT water, so they have moved the cost up for the cheaper water as well.

I: Oh, okay. So it's sort of a side effect that happens. So the water, while they bid higher on the CBT water that then also increases the economic value of other water that isn't CBT?

P: their direct effect right now that we see is only in the CBT piece so if I'm willing to bid $50 an acrefoot and I'll end up by the time that water gets down here I'll have a half acrefoot of water so you basically overpaid by two times what you should for what wet water you'll actually get to put on a field. When they came in and started bidding they went and wanted the water, they wanted to make sure they had the water so they may have bid $200 an acrefoot so if there were any holders of CBT water who were entertaining the idea of leasing, that $200 if they didn't get it they said well in must be worth more than $50 so they would say minimum bid if you want my water is $75 so that's the part that we have seen. As CBT water becomes less available in a dry year, obviously it's going to be a little more of an issue for us. The blessing for us during oil and gas boom that we've seen is that we've only had a 2012 dry year…we had floods in 13 and super wet in 14 and again in 15 so we haven't seen the river with extremely low flows.

Reference 3 - 3.19% Coverage

I: Too late…yeah. So I don't get the sense though in general that the shares bought by oil and gas operators have impacted your access to water?

P: Not yet, there really haven't been enough of them and I can think of 20 shares that changed in the farmers independent…there's talk of some in Western Mutual, but I don't know that that's happened yet. I know they've used PVIC oil and gas companies have used PVIC to deliver their CBT water to farmer's ponds and then draw out of those ponds so I don't know if CBT or PVIC shares that have been sold but I know shares that we talked about before that have been changed to augmentation to try and capture part of the market on the frack side through well pumping to supply the frack.

Reference 4 - 3.06% Coverage

I: So do you feel like you have any protections if there were to be a drought year and there's no protections on the bill dated to maintain your water?

P: no I don't think so.

I: Even with your senior right it's not enough so…

P: Right, right. It's a…a drought like 2012 on an 1864 water right that should have been in constantly, typically they deliver 4 to 5 inches per share of water…in 2012 we were delivering 2 on an 1864 right while an 1870 right had no water.

I: that is so crazy.

P: The hardest part for us is our water rights are all above the confluence of the St. Rain and the platte so we are in the main stand so the (?) water we had in 2012 was what the waste water facilities were putting back in.

Internals\\4_Garfield Transcribed - § 3 references coded [2.49% Coverage]

Reference 1 - 0.90% Coverage

I: yeah especially over there where it's on the south platte, their reaches are going beyond 2 miles now so they are looking at private increase in quantity of water.

P: in an area where there wasn't any extra water, so they're having to take water away from some other source to have that water where here it's more the case that there's generally been most years excess water

Reference 2 - 0.53% Coverage

yeah, and I think you can argue that everybody has their price at a certain time and what they have to pay for that water may increase but if they are willing to pay enough, somebody is going to be willing to lease it to them.

Reference 3 - 1.07% Coverage

I guess I'm gathering that your interests and ability to lease the water to oil and gas isn't really influencing your participation in other leasing arrangements…

P: No, in this area I don't see that as a huge demand. It's going to be such a small percentage of our water that even if it comes back to the level of drilling we had 10 years ago, their water demands…in the long-run the gas in this area can actually produce…be in that producer water.

Internals\\4_Weld Transcribed - § 3 references coded [3.27% Coverage]

Reference 1 - 1.94% Coverage

I don't know if it's a trend but the price has definitely increased. And that's been the interesting thing that the price of ag water and the price of irrigated ground seems to have risen exponentially whereas the commodity prices haven't…so it's interesting, you talk to young guys trying to get into farming and they can't afford to just buy the ground so it's interesting…and I don't know what drives that really…I know the water issue is a supply and demand, you know

when you are buying reservoir shares or whatever and you're competing with somebody who needs it for augmentation, or a municipality, or even oil and gas, they can afford to pay more so it sort of prices it out of ags realm…at least the small family farm anyway.

Reference 2 - 0.99% Coverage

d…there's some equity there on how we treat other water rights holders, whether it's ag or municipal and how oil and gas has been treated as far as the level of scrutiny they have come under for their water use, which I've been very frustrated with that.

I: Yeah. No I sense…as I look at the big picture I get that. There's a little bit of differential access happening.

P: Yeah.

Reference 3 - 0.34% Coverage

I: So have you like in your experience from your perspective, do you see that as being an issue or….

P: it's an issue for ag for sure.

Internals\\5_Weld Transcribed - § 1 reference coded [0.58% Coverage]

Reference 1 - 0.58% Coverage

So availability to lease water had decreased because those leases then were going to oil and gas who were able to pay more than agriculture. So especially for our augmentation was our most critical point

Internals\\6_Weld Transcribed - § 1 reference coded [1.16% Coverage]

Reference 1 - 1.16% Coverage

he said you know we know that in Colorado we're not all equal. We know that because we have different priority dates and different decrees, but we do expect to be treated fairly so within that system, so consequently in this area, in this reach of the river, and this part of the river in Colorado we are treated pretty fairly. We have a very good river commissioner right now,

Internals\\9_Weld Transcribed - § 2 references coded [5.23% Coverage]

Reference 1 - 1.92% Coverage

He's not a farmer. He lives in Denver and he saw a chance to make some money. So he called and said I want to sell my water. So I knew from talking to a few people that there's people interested in buying water who are farming so I put them in contact and let them do their thing. One of the farmers was able to… they were going to sign the contracts this one day. The seller call that morning before the meeting and said I'll have to cancel. I've been contacted by another realtor and he's got a another municipality that's wanting to buy it and it went. So even though you try and do those things, if the money is greater over here for whatever reason they going that direction so.

Reference 2 - 3.31% Coverage

: CBT is multi use. Do you have mostly CBT?

P: the CBT is becoming less and less seven impact here. Years ago there were 15,000 units of CBT in our system, Were down approaching about 3000 now. It's just been sold to municipalities. The cost of, You don't get much water for your money in that system because it's multiple use and other municipalities can pay for that. For instance right now a unit of CBT would be $25,000 or something like that. That gives you on a 70% quota, .7 acre-feet. So your investment cost is 25,000, you're getting less than one acre foot of water forward. On Timnath reservoir investment could be around 16,000 and you're getting 3 acre-feet. So when people look at that and say, man I can sell this and go buy another reservoir and have more water, that's happened quite a bit. Others have decided, I need some money and pay off my farmer whatever. And they sell some of those units. Because they bought those units for 500 or thousand or 5000, You know years ago it's just appreciated 25 or 28,000 now.

MULTIUSE WATER AND CBT WATER MARKETS ARE FLEX IF YOU CAN AFFORD IT… DOESN'T NEC MAKE ECONOMICAL SENSE FOR FARMERS … Flex for some…

Internals\\Bermgardner_interview_7.24.2015 - § 1 reference coded [1.42% Coverage]

Reference 1 - 1.42% Coverage

2002 – no water fighting, had to buy hay for the cattle – made it work
- during this tie, companies were still able to divert Diff Access

CODE: PREVENTING INJURY_MAINTAINING RIGHTS

Internals\\11_Garfield_Transcribed - § 3 references coded [4.73% Coverage]

Reference 1 - 1.97% Coverage

The Yampa is light on administration, the Yampa the white pride themselves on not having administration. A lot of that is really not good for wildlife in the river because people diver more than they need and outfall we forced administration a little bit because there is an instream flow and that is how you would protect water released for a purpose. So they use was in stream flow, we had stored water that had a decree that allowed for that to occur so that was is very expedited process since the decree allowed for instream flow. All we had to do was a phone call in brief letter, coordination with the conservation board to meet they're in stream flow working to dump 20 the 30 CFS and the request to water resources was that you would administer this past headgates. So what's ever there… we want to make sure that gets passed all those headgates because it's stored water in priority, You can't allow anybody to take that.

Reference 2 - 0.59% Coverage

I: so you can only use consumptive use for in stream flows

P: because the people are always entitled to return flows in location and time so all the water had returned down to that lower point of return and that's as long a reach you could really add water to on and in stream program.

Reference 3 - 2.17% Coverage

I: some have, the most recent one I heard some conservative groups down in Arkansas Valley that are concerned about their rights

P: a lot of people still get confused between the diverse and rate and the historic consumptive use… which is the real measure of the value of the water right. It's not how much you take out of the river so that's why some of the attorneys in Carbondale are saying take all this water out you know, or you're going to lose it and meanwhile the water engineers out there are saying it doesn't really matter how much you take out ultimately. It entitles you to take out what you need to grow your crop but you can't waste it. If you have an in efficient means of delivery until someone makes you change it, you can still do that. You might as well read preserve that right, so that's the attorneys battling with the engineers and as a conservation advocate, I'm like you know, You guys should kind a get together an engineering you can actually grow your crops just fine and keep more water in the streams.

Internals\\2_Weld Transcribed - § 1 reference coded [3.85% Coverage]

Reference 1 - 3.85% Coverage

Well, folks are always seeking to maximize their use of say a changed water right…when they change it to ag to municipal we'll say, they quantify both the historic consumptive use and the return flows and they have to maintain those return flows but they can fully consume this for consumptive use, so ways to reuse and successfully use that historic consumptive use folks are always trying to think of a better and more efficient way to do that. If there's a reason not to replace all of the return flows, to keep those and use those…so probably within the last 5 or 6 years there's been a real push in that area to quantify based on when you file your change application in court, a way to keep those return flows…say if the call on the river if the demand by water rights is junior to the date you filed your change application, folks are claiming the right to keep those return flows for their beneficial use as long as…basically…

I: Are you talking about people are claiming potential injury to their rights?

P: No, I'm talking the owners or the people changing the rights are seeking to not replace return flows…basically to get a new junior water right on their return flows so that if you know, as demand continues to grow even though 2015 and 2016 rights would rarely be in priority, recently we've had really wet conditions so they are…and folks are realizing that it may not be a dependable supply but it may be a chance to grab a little bit of an extra supply when it's available and potentially help preserve more senior rights for more dependable supplies for the drier times.

Internals\\6_Weld Transcribed - § 1 reference coded [1.93% Coverage]

Reference 1 - 1.93% Coverage

when they have an idea to do something in water like the flex bill, like the…they immediately see the system and they are unfamiliar with it first of all and second of all they don't necessarily understand why it exists but they just want to do their thing and so the first thing they do is run to the legislature and try to get the rules changed, so that they can do their thing. Does that make sense? Otherwise it wouldn't…if we didn't have this water law that we have in the state of Colorado for very good reason, it's basically for the dry time…that's what the water law is for. When there is plenty of water, it's not a problem.

Internals\\7_Weld Transcribed - § 1 reference coded [1.63% Coverage]

Reference 1 - 1.63% Coverage

It just makes it harder to, I have to keep track of the water on paper too. So I have to make a record for everything. So as soon as something gets split, I've got two records. So it's just more work, more paper work, reviewing the change of plans, going to meeting, talking how are we going to do this now that…. The city of Thornton owns half of Water Supply and Storage and when they start picking up that water, it's going to be a little bit, it's going to be more work involved.

Internals\\Harris_Mark_Garf_9 - § 1 reference coded [1.99% Coverage]

Reference 1 - 1.99% Coverage

Along with a legal perspective, many people thinkg given how senior our water rights are, there was a time when you could own people in this country. So if you think you can't change the water law it would be tough nasty and ugly but it could happen. So the larger context to make sure that we can comply with inter and intra-state agreements so that we don't bring Down any wrath upon us, we certainly attempt to do that.

So thinking legally administratively and in terms management, the water management plan that we're engaging in on the side and the Master Plan that were engaging in on that side, every habilitation of the powerplant, they can't be separated and when we gets the fish recovery itself.. very important with the orchard Mesa check and so on.

CODE: PRIORITIZING WATER FOR AG

Internals\\11_Garfield_Transcribed - § 1 reference coded [0.99% Coverage]

Reference 1 - 0.99% Coverage

There is a lot of turmoil and consternation caused when the instant flow decree end up being the calling right in a river. There is this idea that those rights should be subordinate to human uses whether the human uses are excess or not. It's not just domestic its cows and stock ponds, everything else. If I have to subordinate my used to in stream flows whether it's a decreed use or not there's something wrong about that, that's the perception. And we disagree.

Internals\\13_Garfield_Transcribed - § 1 reference coded [2.72% Coverage]

Reference 1 - 2.72% Coverage

Well to try and tie that in agriculture has been interesting to try to get their partnership with us and you help them understand that we have the same goals as they do and that were not trying to regulate them. Because agriculture really is important to Garfield County, It's part of our heritage, not a lot of people are really making a living doing agriculture… but a lot of people do have branches and are raising cattle and it's just important to us so we want it to be successful, we want to have them participate on the board and we have actually gotten into new board members recently that are part of the agricultural world. So that's been really good. To have them there

Internals\\15_Garfield_Transcribed - § 1 reference coded [2.03% Coverage]

Reference 1 - 2.03% Coverage

well, as far as I'm concerned I own the water rights. The federal government tends to believe differently. The army Corps of Engineers claiming that they have jurisdiction over all the waters of the US. I think that leaves a pretty huge hole in State water rights. I don't know, I hope that all the states will ban together and tell the the federal government to go pound sand.

Internals\\1_Weld Transcribed - § 3 references coded [4.32% Coverage]

Reference 1 - 0.78% Coverage

P: No it was good, the timing was right. They did it in the winter (?) they worked out well.

I: It's funny. Timing can be everything if it was the summer it might not be good…

P: We'd say no way.

Reference 2 - 1.73% Coverage

the big problem I see with leasing is that we use multiparrel crop insurance for hale and any kind of natural storms, which is all federally subsidized so USDA is the one who brings out these policies and they're the ones who deal with it so it's done on your actual production history so you take 10 years, if I grew corn for 10 years I'd take the yield every year and average that out and that's what they would insure for.

Reference 3 - 1.80% Coverage

P: It used to be farmers would lease water to each other so if you and I were farming and you ran a little short I have some extra I could get you and maybe what I have isn't enough to cover your needs but with 2 or 3 other guys it could and then maybe a different year you have excess and I'm short and we used trade back and forth like that all the time.

I: but if they're leasing that water to other uses then is that less…

P: yeah that water is gone.

Internals\\2_Garfield Transcribed - § 4 references coded [6.50% Coverage]

Reference 1 - 3.68% Coverage

I think the biggest issue facing the river district right now is what's happening in Agriculture, and there's enough problems facing agriculture right now, but I think one that's going to be coming to the fore is this issue that the effort going forward, we're really on the cusp of going from a situation where prople are developing new water supplies for new uses and we're going from that to where we are going to be reallocating existing uses. Lake (Pal?), that's a real present example of that and we are in the business right now of going around and looking at ways to reduce use so that we don't suffer the consequences if there's a compact shortage or if Lake Pal goes below minimum power. We want to avoid agriculture on the West Slope being the obvious solution to that. What I say, is that agriculture needs to be part of the solution but it can't be the solution. So if we are suffering shortages in the system, those need to be born in some measure with some equity amongst all (these reservoirs?). So we kind of see a potential bullseye on the

back of agriculture and we want to see the same things happening on the Front Range that are happening here where suddenly we get into it in the environment when we are talking about buying dry agricultural water.

Reference 2 - 0.53% Coverage

if there's a need out there that you can satisfy no matter what the need is and it means that whoever has that need is satisfied and they don't have to compete somewhere else for water

Reference 3 - 1.24% Coverage

So from our perspective we can develop a water supply and that would help energy meet its needs so then it's not out competing for other sources of supply, then that would be great. And that's what I understand is happening in the Front Range on the short-term market, because there's no supplies out there for energy so they go out into the market and acquire water that would have been used for agricultural purposes, right?

Reference 4 - 1.05% Coverage

Now if the water rights go away, the other side of this is that…and if that oil shale develops it in some point in the future, how will they secure the supplies they need. And this is what I get back to, if they are not able to appropriate their own and develop their own supplies of water, it's not going to stop them it's inevitably going to come out of agriculture.

Internals\\2_Weld Transcribed - § 1 reference coded [2.57% Coverage]

Reference 1 - 2.57% Coverage

Are these the same, the reservoir companies and the mutual ditch companies, are they the same members and farmers that are also thinking that maybe it makes economic sense to not grow and to lease?

P: Yeah, some are. There were a few farmers that certainly were looking at that. Probably it was a minority I mean most of the farmers really enjoy farming I think. And they have certainly along in southern Weld Count they are producing fresh vegetables, carrots, onions, potatoes, for the Denver market. They have contracts and to keep…if they let those contracts lapse, there is lots of competition to get those back so they don't…they weren't interested because long-term contract to supply safeway or king soopers with sweetcorn or potatoes for the next 10 years was much more lucrative than a one year deal to not grow something and provide water to an oil company…so a lot of folks who had those kinds of contracts weren't interested but others who didn't didn't have those types of relationships and were more interested, at least a few folks.

Internals\\4_Garfield Transcribed - § 1 reference coded [2.88% Coverage]

Reference 1 - 2.88% Coverage

In our case it hasn't been a problem, the two others who have a right in it actually work in my so they are also employees. That makes it nice, but there could be situations where it wouldn't work that way. My upper place is a little more interesting because the other owner is actually municipality, the Yuke water conservancy district which provides most of the water to the outlining areas around Grand Junction and Grand Valley there and is actually the largest water provider in Wester Colorado. They have purchased a number of ranches up in this area for their water rights and I lease a couple of them from them. In fact the first place they built was in Mesa

in 1977 and when we had severe drought and they realized that if 78 was as bad as 77 they were going to run out of water so they purchased a farm there and my dad ended up leasing that from them and we've had it ever since that farm on Mesa and it's been a good relationship. They want to keep, their biggest concern from a public relation standpoint is that the farm is well taken care of and maintained properly and irrigated properly so as long as we are doing our job, they want to support us doing that job so they've been very good landlords for us.

Internals\\4_Weld Transcribed - § 1 reference coded [0.30% Coverage]

Reference 1 - 0.30% Coverage

…you know when we have a call on the river that means that supply is diminished and ag is needing that to grow crops

Internals\\6_Garfield Transcribed - § 2 references coded [1.34% Coverage]

Reference 1 - 1.05% Coverage

P: most of us are a little more hopeful that agriculture survives, it has value other than just to the landowner. Most of us would rather see some separation between all of this…these cities. Trying to say this as artfully as I can…

I: Are you supposed to be impartial or something…?

P: Well, I am… I mean I, you know as a private citizen I grew up around ranching so my grandpa and my dad were both ranchers so…you know it's just and industry that I think is worth preserving for just the aesthetic value, for the non-ranchers, but whatever.

Reference 2 - 0.29% Coverage

after that it's just going to be pasture because there isn't enough water to irrigate it again. That's the difference between here and weld county.

Internals\\9_Weld Transcribed - § 7 references coded [11.58% Coverage]

Reference 1 - 0.92% Coverage

do you have a standing for keeping water in agriculture versus leasing it to, other uses. Is there some mechanism you have and your organization to assist In that?

P: we've just tried to put buyers… we don't buy and sell here in the office. If someone calls and says I've got some water shares to sell , And I say put an ad out.

Reference 2 - 1.92% Coverage

He's not a farmer. He lives in Denver and he saw a chance to make some money. So he called and said I want to sell my water. So I knew from talking to a few people that there's people interested in buying water who are farming so I put them in contact and let them do their thing. One of the farmers was able to… they were going to sign the contracts this one day. The seller call that morning before the meeting and said I'll have to cancel. I've been contacted by another realtor and he's got a another municipality that's wanting to buy it and it went. So even though you try and do those things, if the money is greater over here for whatever reason they going that direction so.

Reference 3 - 1.32% Coverage

I am afraid that it's just a slow bleed. We can do a lot of things to keep water in agriculture and we're making the effort. But in the long run, Hundred years from now, It's going to be tough. Instead of saying okay, let's sell everything out of agriculture rate now, that's not anything near what we're trying to do but that would be quick and easy. Get it over with. But I think it's going to be a slow bleed I think. Agriculture is going to change through the years.

Reference 4 - 1.62% Coverage

hey individually lease to oil and gas?

P: they do not. All we've been talking about this whole time has been irrigation. We haven't gotten in to oil and gas yet. The CBT is water that can be used for oil and gas. Out of our whole system that's our old water rates. Nothing is there for an gesture to use it's all agriculture. There is fossil creek, if you did anything there you'd have to go through change case in order to get that… our 2001 decree on Cornish planes is for, has decreed uses industrial and commercial and that's our source of that water, for that purpose.

Reference 5 - 1.99% Coverage

So we put some free water in there too. So to be able to use for these purposes as well. It's a very fine line where trying to hold it between… we're in agricultural company and we don't, we don't take water away from farmers… were here to ear gate. That's our number one purpose so we have maintained to this point not taking water away from farmers. And I mean, it's their water so we can't take it without them knowing it. We have been able to provide them all the irrigation water they needed and still been able to use, sell some water for frocking either due to some went years where there was so much water available… or we would Lee's Summit additional water to cover their frocking uses as well.

Reference 6 - 3.24% Coverage

We have to be really careful and I'm probably ultra conservative on this is I can't guarantee out to three years from now that there is water is available for oil and gas. There could be a drought and we've been through them every few years. You get a dry year. So you can't go out and say we're going to provide water for 10 years. It's basically a year to year thing. You're looking at, This is where I'm at. I can do this… so we have not entered into any long-term agreements for anything because of that. You can't guarantee that. If I guarantee 2000 acre feet of water to oil and gas and we have a dry year, I've got guys go on irrigate with that water and I'm going to have to take it away from them and that's not going to work. Because we are an irrigation Company and that's our plan and the oil and gas is supplemental to that it's not the other way around. So we're really trying to be cognizant of all that interplay of the future and then certainty. If I had a big lake up there and it's free river I could be putting thousands of acre-feet in there and then you know, bring it out as I needed to the oil and gas companies. But we don't have that.

Reference 7 - 0.57% Coverage

Our reservoirs fill and empty every year for agriculture. So you just got to work with that, it's kind of tough. You'd really love to, ah man, I'd like to make millions but you got to play it as you go so.

Internals\\Bermgardner_interview_7.24.2015 - § 3 references coded [12.37% Coverage]

Reference 1 - 0.81% Coverage

he seems his job as a commissioner to help keep ag water tights and interests

Reference 2 - 7.98% Coverage

(does this by keeping them out of court) – which is interesting since if PA motivates to go to wourt then not working well, but if are able to negotiate between arguing parties, like he does, and convinve them to figure it out or forget about it, they won't spend all their money in court which is inherent in PA – that farmers would have to pay all the legal fees seems like a contradiction for maintaining water in farming, a low paying,,, *** a system that was made to handle conflicts with handshakes and understanding ??? no, since it was only developed out of conflict, right? So it was developed as a mechanisms to manage conflicts… legally, with lawyers and courts. This is why collab is happening… PA isn't actually working – too damn expensive

Reference 3 - 3.58% Coverage

handshake deals worked for awhile in the CRB, the commissioner helps this happen – a system set up to deal with conflicts, needs the informal to actually work with farmers and the PA legal side should only be utilized in the most fraught cases – when it began , perhaps they were all this way and it's calmed down, people have learned? Idk

Internals\\Harris_Mark_Garf_9 - § 3 references coded [3.78% Coverage]

Reference 1 - 2.25% Coverage

There's something unique about reclamation projects as opposed to private irrigation companies and that is that the lands that were withdrawn from development possibility early on, and the water that we deliver, the association doesn't on the water technically the members don't either. The water is held in titled by the US, put too beneficial use by those who own the property to which it is pertinent. It has to stay with the land it can only be up pertinent to class one lands, 6 lands, etc. originally, not everyone was a farmer but almost everyone was a farmers you probably know the percentages in 1912 1916 but it was a big chunk of Folkes. If they were a farmer and they were no more than one generation away from a farmer. The rule agrarian mindset that everyone shared in allowed… what was good for ag, what was good for farmers, was good for everyone

Reference 2 - 0.58% Coverage

People generally know that if they want to Maintain the astetic environment that they're enjoying now is that they can't trash agriculture agriculture and maintain that. And they can't maintain water and trash that.

Reference 3 - 0.95% Coverage

P: I think what you're getting at is that too many people the aesthetic value of agriculture, rightly or wrongly, is more important than the food value. I know that seems peculiar but that's the truth. So if that's what's important to you as a potential funder, partner, we're gonna talk about that. They're not mutually exclusive. But yeah that's the sad fact.

CODE: SUPPORTING AG BUSSINESS

Internals\\10_Weld Transcribed - § 5 references coded [5.79% Coverage]

Reference 1 - 1.44% Coverage

it's worked out really well. They've drilled a lot of wells in our service area and that's a revenue stream we never had. It makes being on the ditch board really easy. The other day I said you know they're finishing up with that one pad in the invoice is $300,000. The present looked over to the maintenance guy and said order what you need. Just let quick. No discussion, just go order it because they knew they had money coming in.

Reference 2 - 0.41% Coverage

Then when you have this other income coming in, for one thing, they know they're not going to have to raise assessments.

Reference 3 - 0.31% Coverage

So that's like a really good thing, you get the royalties and you also get to sell them water.

Reference 4 - 2.43% Coverage

We still have a good supply of water, That half of percent that we used couldn't… if you spread that over 40,000 acres you couldn't see it. You couldn't even measure it. So they have not noticed that because our supplies are so good right now. If you take just a little bit often that they can't even see it. But what they can see is that the assessments aren't going up. And hopefully maybe they'll maybe go down. And The other thing that they'll see is that we've been able to buy some maintenance equipment, Upgrade. Typically ditch companies, they're like farmers, they use and repair, use and repair. Now we have an extra excavator. Restart one and now we have two. And They're talking about finding another dump truck.

Reference 5 - 1.20% Coverage

Another situation I want to let you know is. Not all of my farmers, A big block of my farmers, And especially on the board, They're probably second or third generation farmers. So they have the minerals under their firm. They're like all over this. You want to join me, yeah you can Drilon me we've got water too. So it's a wonderful thing for your bottom line.

Internals\\15_Garfield_Transcribed - § 3 references coded [9.92% Coverage]

Reference 1 - 0.60% Coverage

Mineral rights – leased and a lot of the new equipment that we have on our ranch is totally a result of oil and gas.

Reference 2 - 3.35% Coverage

Without OG in Plato Valley we still would be going downhill. In The amount of money that oil and gas has generated in the last 15 years is incredible. amount of money in last 15 years is incredible, by paying royalties on wells that are drilled and also by putting people to work. There are so many jobs generated, Secondary Jobs and also directly like here at the restaurant more people being on staff. The RV park down there there's three or four of those campers strictly because of oil and gas. Spraying weeds for the companies and that kind of stuff. So my

interaction with the oil and gas companies have been positive

Reference 3 - 5.96% Coverage

they've had several meetings in Culbran and there's a lot of people that are whining and complaining about the Fracking and that kind of stuff. Most of them are tree huggers, if they don't want boiling gas they should go shut the damn gas meter off their house. We'll see how long it lasts when they've got to take a cold shower the next morning. Because it has to come from somewhere. If they look at it a little bit and become a little more educated when they're drilling these wells that are 7000 feet deep and they're casing them for 10% of the debt. So they're putting solid casing on them 700 or 800 feet. And they're thinking that they're a little pissy ass wells that our 50 feet deep are going to be affected by that activity 8000 feet deep that's cased for 800. They are to look over the fence at their neighbors septic system that's only for her 500 yards away from their well. It's like 8 feet deep and it's leaching out going downhill into the earth to their well that's 50 feet deep. It just pains me to think of these people that they just don't use their brains when they think of those kinds of things.

Internals\\18_Garfield_Transcribed - § 9 references coded [15.44% Coverage]

Reference 1 - 0.80% Coverage

And the oil and gas has been pretty fortunate to a lot of it. In this valley, probably a lot of people went be here if that hadn't developed. There just wasn't enough money in it in the 90s and the 2000's.

Reference 2 - 2.63% Coverage

To answer your question on the generation thing, There's a lot of people kind of getting away from the farming and ranching thing. I think the oil and gas kind of brought some of them back because it was financially, you can afford… and you weren't just barely surviving, scratching by you could actually stay there and live a good life too. The income from that is really substantial, people don't realize just the lease fees and everything else. They can come back and start an operation. It takes so much money to do farming and ranching. People don't realize you couldn't possibly bye these ranches with the money that you can make back from ranching.

Reference 3 - 1.45% Coverage

the pay out on doing the farming wouldn't purchase the land right now. That's why a lot of these places get sold. The oil and gas allowed that margin to get a little closer where people could stay and the next generation can afford to stay there. It's actually keeping a lot of these bigger places together because there's no reason to sell. In this area anyways.

Reference 4 - 2.34% Coverage

I mean it's still a major deal for most of these guys, All the old-timers are still like that but 30 years ago even 20 years ago in this valley your livelihood depended on getting that water to your place. Without it, you weren't getting an income that year. And even to this day that's true to a certain extent but it's not as true as it was because you got the hunting, the recreation, the gas. You're not as reliant on agriculture although that still is a a lot of peoples livelihoods. I don't think people go out there and get it in a fist fight or shoot each other anymore like they used to.

Reference 5 - 0.36% Coverage

I think it's been really beneficial to our community but also I know I has its drawbacks to

Reference 6 - 2.31% Coverage

But like I said, all in all it's been beneficial, it's brought in a lot of jobs. In rifle, when I was in high school it was probably only 3000 people and that wasn't that long ago three or 4000 people and now it's 10 or 12,000 and that tells you what it changes everything. Everything over by Walmart over there, that was the field. That roundabout wasn't there. You can turn left to go to Walmart, none of that was there. You could go straight and then McDonald's and Burger King we're up on the hill but that roundabout wasn't there there was no left turn. That was what 15 years ago.

Reference 7 - 1.33% Coverage

But there's some that clean it up and actually try and do it right, it's been beneficial to us. You be shocked the amount of money these guys get out of boiling gas. The royalties. And just the leases. Thousand bucks an acre or something. Yeah I just to lease the surface rights before they ever drill. That's a pretty typical number.

Reference 8 - 2.27% Coverage

Those gas companies, that's pretty typical, they'll go around the out skirts on these oil fields and they'll buy, there'll lease up the ranches to have them tied up and they'll come back even if they don't drill on it they'll come back in five years and lease it again just so they have it tied up. So they can keep it so no other company comes in there and leases it.

I: I guess that is a little bit of an insurance that they're probably coming back

P: well that's what I mean, the money from it is substantial. That's why say it's kept a lot of the farmers and ranchers afloat.

Reference 9 - 1.97% Coverage

Like with ours we had an agreement for what they would pay us for an amount that was sold to them. We went and actually guarantee it because if we had a drought or something, You know it's still there taking calls water. But if we can provide it for them it's a better deal for them and it gives us another income source.

36:48

and maybe if they're leasing the infrastructure they might have some quantity amount that you have to be able to move in there. In your ditches are pipelines or whatever.

Internals\\2_Weld Transcribed - § 1 reference coded [1.62% Coverage]

Reference 1 - 1.62% Coverage

Many of them put that into needed repairs into the system and the reservoir, the shareholders were going to have a hard time paying for and also in some cases they were able to reduce the annual assessment for operation and maintenance because they had this other source of income. So the oil and gas companies got their water, the farmers may have forgone a little water but they got a lot of return on their investment that may have helped them with their ditch assessments,

may have allowed the company to perform needed maintenance so in a lot of ways, I looked at it and thought maybe it was a win-win situation for both he mutual ditch company and the oil company.

Internals\\3_Weld Transcribed - § 1 reference coded [1.21% Coverage]

Reference 1 - 1.21% Coverage

s long as we have decent water years, the water issue and the demand for water is going to be masked so it's hard for me to say anything other than ag and oil need to work together…them help us figure out ways to use less in times they need more and there's less in the river to get.

Internals\\4_Garfield Transcribed - § 3 references coded [3.50% Coverage]

Reference 1 - 0.41% Coverage

You know you're talking about some farmers not liking the energy development and a lot of it comes down to it if you're the one benefitting from it or just being harmed by it.

Reference 2 - 0.31% Coverage

I've been fortunate that I've had some mineral rights that have paid a little bit. I've basically built this house with gas money.

Reference 3 - 2.77% Coverage

So we can't go back to the way it was 50 years ago, that's not going to happen. But more importantly, I think we look at that past through somewhat rose colored glasses and don't realize what problems were there and missing the opportunities that development brings. And agriculture generally benefits from a strong economy based on other things, whether it's when you look at areas that all they have is agriculture, those areas to a large extent tend to dry up and blow away because changes in technology and agriculture you don't need as many farmers that you used to have and farms are much bigger just because of that technology. You don't have opportunities for young people to stay in a community. The other stores and all the things you need to have a healthy community aren't there. Development brings those things in. I think in the long-run a healthy economy, from other sources, is good for agriculture. We used to say that when you had healthy farms, the community around them would be healthy but I don't know if that's true…it's the other way around…if you have a healthy economy and community the farms in the area are going to be healthier.

Internals\\4_Weld Transcribed - § 1 reference coded [2.42% Coverage]

Reference 1 - 2.42% Coverage

but then there are others who you know it all depends on the ditch company or the board on how they decide to do it…there are others where they are making the money but aren't doing improvements and equipment, so the shareholders on the systems are concerned and complain because they don't see the benefit of what they are doing. They just have this perception that there's less water for me to irrigate with, I'm not benefitting from this. So we've seen both sides of that…the companies that are sharing the wealth so to speak with their shareholders by reduced annual fees or whatever, even the refund in some cases, those shareholders are like hey this is a great thing. The ones that don't see the benefit are calling and saying hey, why are they selling my water, I say you need to talk to your ditch company about that, we don't control what people

can legally do with their water if it's decreed for that source.

Internals\\5_Weld Transcribed - § 1 reference coded [0.58% Coverage]

Reference 1 - 0.58% Coverage

So from your perspective how do these different arrangements with oil and gas companies and water use and stuff worked out?

P: Overall, like I said the benefit to the ditch companies has been very helpful.

Internals\\6_Weld Transcribed - § 2 references coded [1.65% Coverage]

Reference 1 - 0.40% Coverage

I think this oil boom was quicker to react than the past ones and not only was it quicker to react but we got more out of it, you know?

Reference 2 - 1.25% Coverage

There will always be some activity because we all depend on it and if somebody comes along and says who would like to buy some water from you for a frack job or something we would be interested in selling it and the reason why was because we would take that money as a stockholders of the company and we would repair, maintain, or improve our infrastructure for the long-run…so we look at it as beneficial.

Internals\\7_Weld Transcribed - § 1 reference coded [0.90% Coverage]

Reference 1 - 0.90% Coverage

The changes, well some of the big changes would be, in the system, would be, farmers don't have to pay assessments anymore under a bunch of the ditch companies because their royalties are so good. Umm….

I: So mineral royalties?

P: Yeah, that and selling water.

Internals\\8_Weld Transcribed - § 1 reference coded [1.56% Coverage]

Reference 1 - 1.56% Coverage

If they've got a bunch new people they've got to train and teach and do things with, Then they'll be that learning curve again but I think they'll come back. It's a benefit to the water users as well. It's a another revenue source, honestly.

Internals\\9_Weld Transcribed - § 2 references coded [3.87% Coverage]

Reference 1 - 3.45% Coverage

it's been a very beneficial for our system. I mentioned those assessments earlier/… that's the reason I brought them up was we have not had any assessments in our system for the last two years. The farmers are not paying. This money coming in is paying the operating costs of the company. And we have provided a dividend back to them each year, the last two years over and above. So instead of paying, They're receiving money. Still been able to irrigate all they've

wanted, same as they have in the past. We see this as potentially a short little window here. We don't know how long it will last, five years, two, 10 years. But we're trying to take advantage of what the opportunity is there to keep our, get our infrastructure builds up pretty good. We've spend extra on infrastructure. Improvements there while you got the money. We've got some debt, Building that reservoir was not cheap, It was a $7 million investment so… that monies got a come from The stockholders. Well if we can take this and reduce undead you know, 10 years from now there'll be any debt. So when you have to go back to assessments if this oil and gas stuff drops off, then you may be have to come in only at $50 a share. Instead of 100

Reference 2 - 0.43% Coverage

It's really helps in debt reduction, Infrastructure improvements, Obviously providing money to the stockholders. It's been very beneficial.

CODE: VALUING AG CULTURE

Internals\\15_Garfield_Transcribed - § 7 references coded [14.64% Coverage]

Reference 1 - 0.96% Coverage

I mean you had to always fight to get your water everywhere you went's, every day you had to fight to get your water because somebody upstream is takin' it. Anymore nobody cares.

Reference 2 - 1.81% Coverage

P: I think the state is trying to do a whole lot more with less. It used to be they had to ditch rider on every creek and those ditch riders were well respected throughout the community. If they turned your water off it was off. They understood the priority system and now I see people come from grand junction to try to administrate water.

Reference 3 - 3.37% Coverage

and without that local community connections, I think there's a call put on the creek a lot more often just because nobody's there to manage it and by the end and care about it. You said there aren't as many people, there are as many people using it, They're just not using it effectively. There'll out there and they all want their water. They may have a little acre or two acres of hay for their horse… this whole valley has turned into 60 or 70% hobby farmers. They're dependent on somebody else to come harvest and they'll their hay. They don't want to have to own equipment equipment to maintain the acreage that they have.

Reference 4 - 0.64% Coverage

Personally I just see our country in a state of demise because we're so dependent on everybody else to produce stuff.

Reference 5 - 2.25% Coverage

If you allow all the agricultural water to be converted to me just pulling in industrial, Hell we'd be selling it to Nevada and this whole place would dry back up. It would be the desert that it was in 1900s hundreds before the highline Canal and the grand Valley Canal and everything we put in. In interest of our country staying somewhat self sufficient I don't want to see those agricultural Rights to be converted.

Reference 6 - 2.94% Coverage

so you don't have a lot of young farmers around here?

P: there's not a lot now. Every class that graduates from Plato Valley that has 25 kids in it, two or three at the most might stay around and doing something on a farm or ranch. Right now the price of land is so cost prohibitive for a kid getting out of school, never be able to think about buying a piece of property and making a go at it. I don't see any possible way. If I hadn't worked on a ranch my entire Life and had a big part of a well to me, There's no way, No possible way I could own what I own today.

Reference 7 - 2.66% Coverage

You know our society is so much different than it was 20-30 years ago. There's so many other things that draw Young fellas to tick now. You got to have a boat, got a have a four wheeler, Got to have a snowmobile and then you got to go skiing and pretty soon I'll your money is dedicated to all these payments for all the play toys you got have for every weekend and and I don't know. The focus of the United States population is so far removed from were it was 40 years ago. I don't know how you could ever…

Internals\\9_Weld Transcribed - § 2 references coded [2.60% Coverage]

Reference 1 - 0.87% Coverage

The farmer still has to own that water are be able to lease that back and still be able to make his decisions on his farm. You know, it's not just, If you're making hats you pull the plug and you don't buy anymore supplies. A farm is different… it's not just shutting down, It's a way of life for these people.

Reference 2 - 1.73% Coverage

you know, the water bank, is there a way where if someone has extra shares they can sign it over to this bank and someone can say they want to lease them. You're not going to have your typical farmer doing that. Unless the money is really there to be able to do that. Farmers farm, That's what we do. Well, some of the younger guys coming in this is their second third fifth sixth generation. I've got one farm that six generation. They want to farm. They want their grandkids. You'll see some that I have a job in town maybe and a different outlook on it is not the farm has always been… you see some changes there

Internals\\Bermgardner_interview_7.24.2015 - § 1 reference coded [2.00% Coverage]

Reference 1 - 2.00% Coverage

He is the water commissioner between Glenwood and Kremmling in Grand, Routt and Eagle Counties, he likes this since he can be at home more with fam instead of out at ranch for half the week.

Internals\\Smith Stephen interview12.22.2015 - § 1 reference coded [11.40% Coverage]

Reference 1 - 11.40% Coverage

- land man – concerned that would roll contract to one of big players – if signed below at cost could have gotten

- Synergy: signed contract, more credible,
- neighbors got into rhetoric about water contamination from fracking – got out of hand.
- he thinks engineering and tech solutions that could mitigate

- Pace property -

- could have leased water but issue would have been more contentious in community

- daughter is very concerned from enviro standpoint –
- mostly hobby farmers so not as likely to happen

- Nat Geo article –

Internals\\Spalding_Garf_7_21_2015 - § 1 reference coded [2.33% Coverage]

Reference 1 - 2.33% Coverage

Participates in the watershed coalition, asked by Maria P and Laurie to represent a farming perspective – born and raised in Rifle – 34 years there –
They are extremely active compared to the Silt Board

APPENDIX C

DATA TABLES

These data tables belong to Chapter 2: *Accessing Flexibility: A Historical Institutional Analysis Of Water Use for Oil and Gas Development in Colorado.* Data for water rights (degrees) and short-term leasing agreements (SWSPs) is organized by county.

Company Name	Case #	WDID	Water Right Name	Date Decree Signed by Water Judge	Appropriation Date	Water Source	Changed From	Decreed Use(s)	Max Decreed Rate/Amount (cfs)	Total Volumetric Limit/Amount (AF/Yr)
A&W Water Services, Inc.	05CW0040	206124	A&W WATER WELL 66220-F (FARR FARMS WELL 31-3 R-13416 on Hydrobase) (Previously: FARMERS INDEPENDENT DITCH)	Jan 8 2010, enteredd nunc pro tunc Dec 18, 2009	10/8/2004	Ground water tributary to SP	Irrigation	Industrial & Commercial	.44 absolute 1.79 conditional	650 (w/ Well 66221-F)
	05CW0040	206115	A&W WATER WELL 66221-F (FARR FARMS WELL 31-2 R-13417/RF 762 on Hydrobase) (Previously: FARMERS INDEPENDENT DITCH)			Ground water tributary to SP	Irrigation	Commerical & Industrial	.28 cfs absolute 1.92 cfs conditional	650 (w/ Well 66220-F)
	03CW0416	205327	BATEMAN WELL 61793 (Previously: BATEMAN WELL 03250-F)	18-Jan-2005	2/1/1997	Ground water tributary to SP	NOT A CHANGE CASE - Conditional rights tumed absolute	Commerical & Industrial	1.114 (absolute via this decree)	500 g.p.m. (=807.04 AF/Yr)
UB Water, LLC & A&W Water Services, Inc	12CW0090 (now consolidated with 11CW0122)	208430	Ulrich Well No. 133 Industrial Right ("Ulrich Well No. 133)	APPLICATION	3/9/2012	Depletions to SP (Apps/SWSPs state "alluvial ground water formation" followed by coordinates)	Irrigation	PROPOSED uses: industrial equipment washing, O&G exploration, development, reclamation & dust suppression in Larimer, Weld, Boulder, Jefferson, Broomfield, Morgan, Adams, Arapahoe, Douglas, Elbert & El Paso counties (Permit # 76132 for uses issued 6/7/12; receipt # 3654855)	3 (conditional)	2,190
	12CW0090 (now consolidated with 11CW0122)	210299	Ulrich Fish Pond Well Industrial Right (Ulrich Fish Pond Well)	APPLICATION	3/9/2012	Depletions to SP (Apps/SWSPs state "alluvial ground water formation" followed by coordinates)		PROPOSED uses: industrial equipment washing, O&G exploration, development, reclamation & dust suppression in Larimer, Weld, Boulder, Jefferson, Broomfield, Morgan, Adams, Arapahoe, Douglas, Elbert & El Paso counties (Permit # 76132 for uses issued 6/7/12; receipt # 3654855)	1.34 (conditional)	979
Cache La Poudre Irrigating Co.	01CW0201	103009	CORNISH PLAINS RESERVOIR & RECHARGE FACILITY	3-Nov-10	9/17/2001	CACHE LA POUDRE RIVER	NOT A CHANGE CASE - Request for storage rights for 2 structures, surface & drainage water rights, & recharge rights	Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife		1500 (2,655 AF total for Cornish Plains Res)
					12/19/2002			Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife		700 (347.7 absolute + 352.3 conditional) (2,655 AF total for Cornish Plains Res)
					12/29/2004			Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife		455 (2,655 AF total for Cornish Plains Res)
		300772	NEW CACHE COLE BANK DRAW DIVERSION		9/17/2001	COAL BANK DRAW		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife	75	
		300773	NEW CACHE EATON DRAW DIVERSION			EATON DRAW		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife	100	
		100872	NEW CACHE GALETON DRAW DIVERSION			DRAINAGE		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife	20	
		300771	NEW CACHE JOHN LAW SEEP DITCH DIVERSION			DRAINAGE		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & evaporation	50	
		102361	NEW CACHE NORTH BARNSVILLE 068 RECHARGE AREA			CACHE LA POUDRE RIVER		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife		300
		100873	NEW CACHE OWL CREEK DIVERSION			OWL CREEK		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife	14	
		102348	NEW CACHE SOUTH BARNSVILLE 067 RECHARGE AREA			CACHE LA POUDRE RIVER		Irrigation, commerical, industrial, recreation, fishery, augmentation, recharge & wildlife		300
Clyde E. Folles Trust & Ruth M. Folles Trust	02CW0215	109855	FOILES LAR WL FLD	3-Dec-03	9/30/2002	Nontributary groundwater from Lower Arapahoe Aquifer	NOT A CHANGE CASE - Adjudication of non-trib groundwater rights	Irrigation, commercial, industrial, recreation, fishery, fire, domestic, stock, augmentation, snow making, power generation & wildlife		24.6 (absolute)
	02CW0215	109856	FOILES LFH WL FLD			Nontributary groundwater from Laramie-Fox Hills Aquifer		Irrigation, commercial, industrial, recreation, fishery, fire, domestic, stock, augmentation, snow making, power generation & wildlife		55.8 (absolute)
Great Western Development & Poudre Tech Metropolitan District	08CW0065	300930	WHITNEY IRR DITCH (112 shares - "Great Western Shares")	Entered October 24, 2011 - Clerically ammended October 25, 2011	09/01/1862	Cache la Poudre River, tributary to SP River	Irrigation	Irrigation, municipal, commercial, industrial (incl process water), domestic, fire, fishery, augmentation & snow making	16.88	3,667.30
					09/10/1871	Cache la Poudre River, tributary to SP River	Irrigation	Irrigation, municipal, recreation, industrial, commercial, fishery, fire, domestic, augmentation & power generation	4.53	
			WHITNEY IRR DITCH (16 shares - "Poudre Tech Shares")	Entered October 24, 2011 - Clerically ammended October 25, 2011	09/01/1862	Cache la Poudre River, tributary to SP River	Irrigation	Irrigation, municipal, recreation, commercial, industrial, fire, fishery, domestic, augmentation & snow making	2.41	523.9
					09/10/1871	Cache la Poudre River, tributary to SP River	Irrigation	Irrigation, commercial, fishery, wildlife, industrial, fire, augmentation, power generation, municipal & recreation	0.65	
Tollco, Inc (later become property of Poudre Tech)	02CW0390	300931	B H EATON DITCH (114 Shares)	26-Sep-07	04/01/1864	Cache la Poudre River	Irrigation	Irrigation, municipal, commercial, industrial, recreation, fishery, domestic, storage, augmentation & wildlife	17.28	3,755
					06/01/1866	Cache la Poudre River	Irrigation	Irrigation, municipal, commercial, industrial, recreation, fishery, domestic, storage, augmentation & wildlife	1.98	
					07/25/1872	Cache la Poudre River	Irrigation	Irrigation, municipal, commercial, industrial, recreation, fishery, domestic, storage, augmentation & wildlife	5.5	
		300930	WHITNEY IRR DITCH (40 Shares)		09/01/1862	Cache la Poudre River	Irrigation	Irrigation, municipal, commercial, industrial, recreation, fishery, domestic, storage, augmentation & wildlife	6.03	1,310
					09/10/1871	Cache la Poudre River	Irrigation	Irrigation, municipal, commercial, industrial, recreation, fishery, domestic, storage, augmentation & wildlife	1.62	
Front Range Feed Lots, LLC	06CW0114	305912	SWANSON WELL 8697	March 30, 2010, entered nunc pro tunc March 5, 2010	5/14/2008	GROUNDWATER	Irrigation	Commercial, industrial & domestic	2.44	10 (conditional)
Select Energy Services, LLC	11CW0290	103015	WEITZEL POND 1	17-Jun-13	12/19/2011	COAL BANK DRAW (Decree states: An unnamed tributary to Coal Bank Draw tributary to Greasewood Draw tributary to the South Platte River)	NOT A CHANGE CASE - Lessee seeking conditional appropriation of water for storage & use, & asking to store conditional water in 2 ponds on leased land	Irrigation, commercial, industrial, domestic & stock	5	35 (conditional, with right to fill & refill)
	11CW0290	103016	WEITZEL POND 2		12/19/2011	COAL BANK DRAW (Decree states: An unnamed tributary to Coal Bank Draw tributary to Greasewood Draw tributary to the South Platte River)		Irrigation, commercial, industrial, domestic & stock	10	18 (conditional, with right to fill & refill)
Sorin Natural Resource, LLC & Big Thompson Investment Holdings, LLC	12CW0179		Big Bend Ditch (via Union Ditch Headgate)	APPLICATION			Irrigation	PROPOSED uses: Irrigation, commercial & industrial, including storage & recharge	4	
	12CW0179		38 Godfrey Ditch (aka Section # 3 Ditch) Shares	APPLICATION			Irrigation	PROPOSED uses: Irrigation, commercial & industrial, including storage & recharge	"The 38 shares that are the subject of this Application equals a pro rata interest of 23.75% of the waters diverted by this ditch." (p.5/37 of app) - See Notes section	
Sorin Natural Resource, LLC & Big Thompson Investment Holdings, LLC	12CW0179		Hickman Wellfield	APPLICATION	Initial = July 31, 2012	Ground water tributary to SP	NOT A CHANGE CASE - New conditional underground right	PROPOSED uses: irrigation (no more than 30 acres), commercial & industrial uses, including storage & recharge	1,500 gmp (= 3.34 cfs, conditional)	3,000
Lower Latham Reservoir Co	13CW3057		Lower Latham Ditch	APPLICATION		South Platte River	Irrigation	PROPOSED uses: Irrigation, industrial & commercial, including but not limited to use in O&G exploration & development, municipal, domestic, augmentation, replacement & recharge		403.5 AF/Yr
	13CW3057		Lower Latham Drain	APPLICATION		"Waste water & percolating drainage & seepage water gathered along its course" (p.2/9 on app)	Irrigation	PROPOSED uses: Irrigation, industrial & commercial, including but not limited to use in O&G exploration & development, municipal, domestic, augmentation, replacement & recharge		

Green = oil and gas use
Gold = likely related to oil and gas use